THE

POPULAR SCIENCE MONTHLY.

JANUARY, 1879.

TRACES OF AN EARLY RACE IN JAPAN.

By EDWARD S. MORSE.

THERE is no race of people in whose origin we are more interested than in that of the Japanese. Their history going so completely back for nearly two thousand years, their civilization, which in so many respects parallels our own—the various epochs in our history being typified again and again by similar ages in Japan—all excite our deepest interest. The difficulty of tracing out ethnical affinities either through their personal peculiarities or their language presents a problem yet unsolved. That they are a composite race we cannot doubt. All their traditions point to their coming from the south, and equally sure are we that when they landed they found a hairy race of men to contest their occupation. Later history shows that a number of Chinese invasions took place, and these unwelcome visits were returned by the Japanese. Corea was invaded by the Japanese long ago. With these facts in mind, we are no longer surprised at the great variety of faces to be met with in Japan—faces purely Chinese; others with the coarser features of the northern tribes; and again the delicate and pleasant features of what is supposed to represent the typical Japanese.

The conjectures and opinions that have been advanced regarding the origin of the Japanese would form a curious and bulky collection. It is worth noting that both pagan and Christian writers have held almost equally preposterous notions regarding the origin of the Japanese. The people themselves have a tradition that they owe their origin to the sun. Kämpfer holds the absurd idea that "they are descended from the first inhabitants of Babylon." From these vagaries we pass in turn to other ideas based on some foundation of fact. In a paper read before the Asiatic Society of Japan by Mr. Aston, an affinity is

shown to exist between certain words in the Japanese and Aryan; while Mr. Brooks, in the proceedings of the California Academy of Sciences, takes ground for believing that the Japanese and Chinese may have been derived from the west coast of South America. Mr. Isawa, an intelligent Japanese student, at the last meeting of the American Association for the Advancement of Science, called attention to the simi-

Fig. 1.

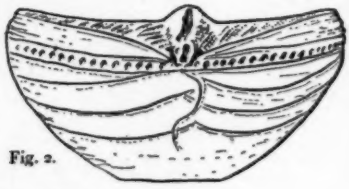


Fig. 2.

Fig. 3.

Fig. 5.

Fig. 4.

Fig. 6.

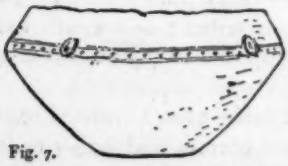


Fig. 7.

Fig. 8.

Figs. 1 to 9 show some of the various forms of vessels. Fig. 1, diameter, 130 mm. Fig. 2, diameter, 280 mm. Fig. 3, diameter, 130 mm. Fig. 4, height, 290 mm. Fig. 5, diameter, 105 mm. Fig. 6, diameter, 160 mm. Fig. 7, diameter, 150 mm. Fig. 8, diameter, 150 mm.

larity existing between many Japanese words and Hindostanee. With these and many other conflicting views, authorities seem to agree upon one thing, and that is, that the present inhabitants of Japan are not autochthonous, neither the Japanese nor the Ainos in Yesso.

So far as the ancient records of Japan are to be relied upon (and they certainly go back before the Christian era with considerable accuracy), Jimmu Tenno in the first century of our era came from a province in Kinshin for the conquest of Niphon or Japan. The invaders met with so courageous a resistance that they were obliged to go back to their own shores. The people who repulsed Jimmu Tenno and his followers are believed by the Japanese to have been the hairy men of Yesso, the ancestors of the present inhabitants of the northern islands.

The study of the language, traditions, and folk-lore of the Ainos, furnishes good reasons for believing that the ancestors of the Ainos came from Kamtchatka, drifting down through the Kuriles, and gradually becoming proprietors of the soil before the Japanese came from the south to displace them.

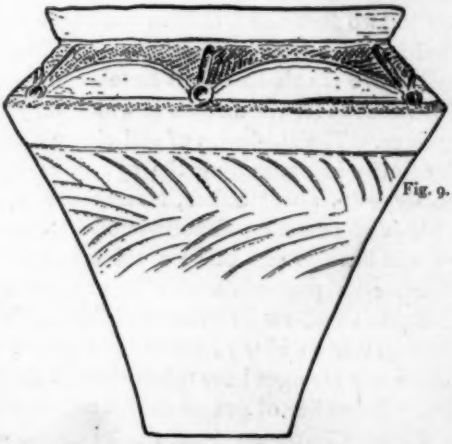


Fig. 9.

Fig. 9—the rims of this vessel are quite common in the heaps, but only one, the fragments of which could be matched, was found. Its height was about 300 mm.

With every reason for believing that the Japanese came from the south, displacing the Ainos, who came from the north, the question next arises as to the original occupants of the island. Did the northern people encounter resistance from a primitive race of savages, or were they greeted only by the chattering of relatives still more remote, whose descendants yet clamber about the forest-trees to-day? The records are silent on these points. A discovery that I made in the vicinity of Tokio last year leads me to believe that possibly the traces of a race of men previous to the Aino occupation have been found. I say possibly, because a study of the Aino people, their manners, and traces of their early remains, is necessary before a definite opinion can be formed.

On my first visit to Tokio I discovered from the car-window a genuine "Kjoekkenmoedding," or shell-heap, as we call them. The deposit is in Omori, about six miles from Tokio; and one may well wonder why it had not been recognized before. It had probably often

been seen, but, like many similar deposits in Europe and America, had been looked upon as natural beds of sea-shells deposited in past times, and after their formation elevated by upheaval. It was not until Steenstrup, of Copenhagen, first took up the critical study of similar deposits along the shores of the Baltic, and showed that the deposits were really the work of man, and of ancient man, that attention was attracted to these beds in other parts of the world.

Thanks to several years' study of these deposits along the coast of New England, in company with Prof. Jeffries Wyman, I was enabled to recognize the character of the Omori deposit at once. The railway passes directly through it, and most of it has been removed for ballasting the road. The bed evidently covered the field beyond the track for a considerable distance, judging from the quantity of shells and fragments of pottery which were strewed in the adjacent rice-field. The deposit varied from a few inches to two feet and a half in thickness, and the layer of earth above varied from two feet to nearly five feet in thickness. This great depth of soil above the shells might have been brought in by man, as the Japanese are famous for the manner in which they level the ground and fill in depressions. The thickness of soil above a deposit is always an untrustworthy guide in estimating the age of such a deposit: as, for example, the deposits about Salem, Massachusetts, containing precisely the same kinds of pottery and bone-implements, and presumably of the same age, will have in one place a thickness of two feet of soil above, and in the sterile pastures a thin layer of a few inches. The Omori deposit is made up of shells which still live in the bay of Yeddo, though I have not yet been able to study the living forms sufficiently to ascertain whether any changes have taken place in the fauna since the heaps were made. A number of genera are found, representing, among others, *Eburna*, *Turbo*, *Ceritheum Arca*, *Pecten cardium*, two species of *Ostrea*, and, curiously enough, large valves of the common clam, *Mya arenaria*, hardly to be distinguished from the same species so common along the New England coast. The position of the Omori heap is striking. The shell-heaps of New England, Florida, and nearly all places where they have been observed, are always in immediate proximity to the shore or river. In some places, as at Goose Island, Maine, the ocean encroaches upon the deposits and is gradually removing them. Rev. James Fowler, in commenting upon the absence of shell-heaps along the New Brunswick coast, offers this as one of the evidences that the sea is encroaching upon the land, and calls attention to the fact that buildings, which stood at some distance from the shore fifty years ago, have since been washed away.[1] Along the shores of the Baltic, the shell-heaps, on the contrary, are a mile or more from the shore, and this fact, with evidences of a geological character, shows a practical encroachment of the land upon the sea by upheaval since the deposits were made.

The Omori deposits, like those of the Baltic, are some distance from

[1] "Smithsonian Annual Report" for 1870, p. 389.

the sea-shore—nearly, if not quite, half a mile. And that an upheaval has taken place since the deposits were made, there can be no doubt. Geological evidences are not wanting to support this view; these various deposits, remote from each other, such as the Denmark, New England, and Florida deposits, have each their peculiarities. In the Danish heaps there seems to be a scarcity of pottery, but an abundance of flint-chips and rude stone implements, as well as implements worked out of horn and bone. The New England shell-heaps are not rich in pottery fragments, the stone implements are rude and scarce, but the implements of horn and bone are comparatively not uncommon, those worked out of bone being more common. In the Florida deposits fragments of pottery are more abundant; and while rude stone and bone implements are found, the larger shells seem to have furnished them with material for many of their implements. Prof. Wyman has figured many of them in his memoir on the fresh-water shell-heaps of Florida, and Dr. Stimpson has figured an awl in the *American Naturalist*, which was made out of the spirally grooved columella of *Fasciolaria*. While the pottery of Denmark and New England is ornamented by incised lines and "cord-marks," the Florida pottery bears the marks of stamps by which they impressed a rude ornamentation upon their vessels. The Omori shell-heap has also its peculiarities: 1. The extreme abundance of pottery, both in fragments and nearly perfect vessels. From the great quantity found there, one is led to believe that in past times it was a famous place for its manufacture. Yet in the excavations no masses or unfinished vessels were found to justify this assumption. 2. The great variety in the form of the vessels and remarkable diversity in their ornamentation. From these characters alone one might infer it to be of more recent origin. Its rudeness, however, and the absence of anything like lathe-work or glazing, show it to be ancient.[1] A greater portion of the pottery has the twisted cord-mark so common in most of the early pottery. Much of it has incised lines, and small fragments show a peculiar carving, made after the clay was dry, but before baking.

The ornamentation in these fragments is almost precisely similar to the Aino style of ornamenting. In other pottery also the peculiar way in which spaces between curved lines are "filled in," either by "cord-marks" or punctures, again recalls the Aino. And had nothing else been found in the deposit, the remains might have unhesitatingly been referred to the Yessoines. Such comparisons are unsafe, as Mr. Frank H. Cushing, of the Smithsonian Institution, finds similar pottery

[1] A writer in one of the Yokohama papers calls attention to the fact that a fragment of glazed pottery was found, when the excavations were first made, against the exposed bank of the railway. He might have added that an English button and the soldered disk of a tin preserving-can were also found! Such a one, finding a living toad in a granitic crevice, would be likely to infer, either that the toad was as old as the granite, or that the granite was as recent as the toad.

in Northern New York and Canada, and I may add that in New England such pottery has been found. In many cases the borders of vessels are ornamented with undulating ribs, showing the marks of "finger-squeezing." A marked peculiarity of the pottery consists in the eleva-

Figs. 10 to 17 show a few of the knobs or handles which are peculiar to the Omori deposit. Not a single vessel was found with legs, as with the Central American pottery, but most of the vessels have raised knobs on the margin. Fig. 16 is looped, so that a wooden handle might be adjusted. Fig. 11 is 190 mm. in its longest diameter; the size of the other knobs may be estimated from this.

tion of the rim or border into ornamented knobs or handles, some of which are represented in Figs. 10 to 17 inclusive. Some painted pottery was also found, the coloring matter of which, on analysis by Prof. Jewett, of the Imperial University of Tokio, proves to be cinnabar. The

occurrence throughout the empire of stone celts, finished arrow-heads, and spear-points and pestles, is common. These might or might not have belonged to the Ainos, though, as similar forms occur in Yesso, the probability is that many of them at least are of early Aino manufacture. It is significant, however, to observe that the few stone implements found in the Omori beds are of the rudest manufacture; and, furthermore, that no shell-heap that I know of has revealed a less number, the two shown in Figs. 28 and 29 being made of a soft volcanic rock. Curiously enough, most of the other implements were made out of deer's-horns, only one being of bone (Fig. 21, evidently the end of a deer's metatarsal). An exquisitely finished arrow-point (Fig. 25) was fabricated out of a boar's tusk.

The bones of birds were not common. I searched in vain for traces of the great auk, the remains of which are so widely met with in Denmark and New England. Though ponderous shells of various species occur in the heap, no evidence was found that these were worked in any way.

Fig. 18.

Fig. 19.

Fig. 18 is a piece of pottery that may be a spindle-whorl—diameter, 70 mm.
Fig. 19 is a small clay brick, 55 mm. in length. This is ornamented on both sides. It is difficult to conjecture its use. I have four more in the collection at the university, much larger and ornamented in a different manner. These are possibly amulets, or perhaps signs of office or authority. I think they are unique.

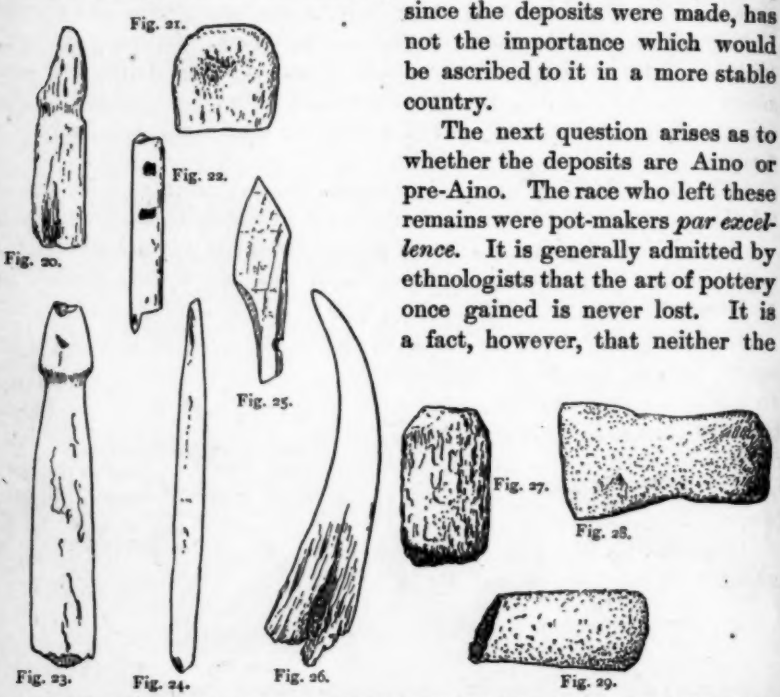
A fragment of a spindle-whorl is shown in Fig. 18. A peculiar tablet, or brick of clay, curiously ornamented, is shown in Fig. 19. Nothing of the kind, so far as I know, has been found in the shell-heaps of other parts of the world. It is difficult even to conjecture its use.

The most important discoveries connected with the Omori deposits are the unquestionable evidences of cannibalism. Large fragments of the human femur, humerus, radius, ulna, lower jaw, and parietal bone, were found widely scattered in the heap. These were broken in precisely the same manner as the deer-bones—either to get them into the cooking-vessel, or for the purpose of extracting the marrow—in all respects corresponding to the facts cited by Wyman in proof of the evidences of cannibalism found in the Florida and New England shell-heaps.

The question as to the antiquity of the Omori deposits naturally arises, and the evidences all point to a considerable antiquity, suggested by the entire absence of worked metals, as well as of finished or polished stone implements, the few implements found being of the rudest character.

The change which has taken place in the coast-line by upheaval, since the deposits were made, has not the importance which would be ascribed to it in a more stable country.

The next question arises as to whether the deposits are Aino or pre-Aino. The race who left these remains were pot-makers *par excellence*. It is generally admitted by ethnologists that the art of pottery once gained is never lost. It is a fact, however, that neither the



Figs. 20 to 26 represent a number of implements made out of horn, with the exception of Fig. 25, which is worked out of a boar's tusk. Figs. 23, 24, and 26, are respectively 60, 62, and 125 mm. in length. Fig. 21 is worked out of the end of a deer's metatarsal. Fig. 22 is a bird's bone, probably a humerus, with two holes worked in it.

Fig. 27 is a portion of deer's antler cut at both ends and broken,

Figs. 28 and 29 are two stone implements, worked out of soft lava-rock. They are respectively 50 and 70 mm. in length.

Esquimaux, Aleutians, Kamtchadales, nor the Ainos, are essentially earthen-pot makers, their vessels being usually wrought out of stone or wood, and their ancient stone vessels are often met with in various parts of Japan.

If the unquestionable resemblance between the ornamentation of some of the fragments and similar styles of ornamentation among the present Ainos be looked upon as indicating a community of origin, what shall be said of the following figures of knobs found in a shell-heap on the Upper Amazon by the lamented Prof. Hartt? The knobs themselves are so unlike anything figured heretofore, and yet so precisely do they resemble similar knobs which are most common in the Omori deposits, that were they mixed with the collection it would be

impossible to separate them by a single character!—even to the depression on top and in front, as shown in Fig. 12.

A curious stone ornament, having the general shape of a comma, with the big end perforated, is known as the *magatama*. These peculiar-shaped objects are looked upon as ornaments belonging to the primitive inhabitants of Japan. Mr. Borlase[1] says the traditions about them have been handed down from mythological times.

Siebold says: "To this day they are in use among the Ainos of Yesso and in the Kuriles, as precious ornaments, under the name of *sitogi*. The inhabitants, too, of Liukiu wear a stone resembling the *magatama;* so that this little jewel helps us to a noteworthy historic fact, namely, to the connection which in remote times existed between the inhabitants of the whole chain of islands from Taiwan to Kamtchatka."

An exhaustive examination of the Omori deposits did not reveal anything like a *magatama*.

Were the Ainos cannibals?

Repeated inquiries among eminent Japanese scholars and archæologists, like Mr. Kanda, Mr. Ninagawa, and others, as to this question, are always answered in the same way. Not only were they not cannibals, but they are reported as being so mild and gentle that murder was never known to have occurred. So monstrous a habit would certainly have been known and recorded, particularly in the painstaking annals of early historians.

In conclusion, then, the Omori shell-heap presents all the leading characteristics of the typical Kjoekkenmoedding. And the evidences

Fig. 30.

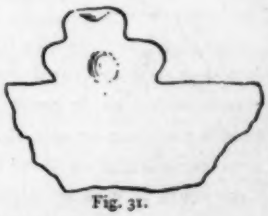


Fig. 31.

which Prof. Wyman cites as evidence of cannibalism, in the shell-heaps of Florida and Massachusetts, are likewise present in the Omori deposit. The recent occupation of America by the white race renders it difficult to determine how recent the shell-heaps along the coast may be, since the savages when first encountered were living in much the same condition as their ancestors had lived, just as to-day there still exist in some parts of the world veritable Stone-age savages. In Japan, however, where historians have chronicled with remarkable fidelity the minute details of their history, we get, as it were, some standard for

[1] "Niphon and its Antiquities."

time in estimating the age of the Omori deposits. It can be stated with absolute certainty that they are pre-Japanese; and there are as good reasons for believing them pre-Aino as early Aino.

I have to return my sincere thanks to the university authorities for the zeal they have displayed in assisting me in the examination of the deposits, and to the personal help afforded me in the excavations by Profs. Yatabe, Toyama, and Dr. David Murray, Messrs. Matsumura, Sasaki, Matsura, Fukuyo, and others. I made a special request that the deposits should be completely examined during my absence, and this examination was most faithfully done. A much larger collection was made with many new and curious forms of pots. I hope at some future time to illustrate them.

VIRCHOW AND EVOLUTION.[1]

By Professor JOHN TYNDALL.

THIS world of ours has, on the whole, been an inclement region for the growth of natural truth; but it may be that the plant is all the hardier for the bendings and buffetings it has undergone. The torturing of a shrub, within certain limits, strengthens it. Through the struggles and passions of the brute, man reaches his estate; through savagery and barbarism his civilization; and through illusion and persecution his knowledge of Nature, including that of his own frame. The bias toward natural truth must have been strong to have withstood and overcome the opposing forces. Feeling appeared in the world before knowledge; and thoughts, conceptions, and creeds, founded on emotion, had, before the dawn of science, taken root in man. Such thoughts, conceptions, and creeds, must have met a deep and general want; otherwise their growth could not have been so luxuriant, nor their abiding power so strong. This general need—this hunger for the ideal and wonderful—led eventually to the differentiation of a caste, whose vocation it was to cultivate the mystery of life and its surroundings, and to give shape, name, and habitation to the emotions which that mystery aroused. Even the savage lived, not by bread alone, but in a mental world peopled with forms answering to his capacities and needs. As time advanced—in other words, as the savage opened out into civilized man—these forms were purified and ennobled, until they finally emerged in the mythology and art of Greece:

> "Where still the magic robe of Poesy
> Wound itself lovingly around the Truth."[2]

[1] Introductory chapter to a forthcoming volume of "Fragments of Science."

[2] "Da der Dichtung zauberische Hülle
Sich noch lieblich um die Wahrheit wand."—Schiller.

As poets the priesthood would have been justified; their deities, celestial and otherwise, with all their retinue and appliances, being more or less legitimate symbols and personifications of the aspects of Nature and the phases of the human soul. The priests, however, or those among them who were mechanics and not poets, claimed objective validity for their conceptions, and tried to base upon external evidence that which sprang from the innermost need and nature of man. It is against this objective rendering of the emotions—this thrusting into the region of fact and positive knowledge, of conceptions essentially ideal and poetic—that science, consciously or unconsciously, wages war. Religious feeling is as much a verity as any other part of human consciousness; and against it, on its subjective side, the waves of science beat in vain. But when, manipulated by the constructive imagination, mixed with imperfect or inaccurate historic data, and moulded by misapplied logic, this feeling traverses our knowledge of Nature, Science, as in duty bound, stands as a hostile power in its path. It is against the mythologic scenery, if I may use the term, rather than against the life and substance of religion, that Science enters her protest. Sooner or later among thinking people, that scenery will be taken for what it is worth—as an effort on the part of man to bring the mystery of life and Nature within the range of his capacities; as a temporary and essentially fluxional rendering in terms of knowledge of that which transcends all knowledge, and admits only of ideal approach.

The signs of the times point in this direction. It is, for example, the obvious aim of Mr. Matthew Arnold to protect, amid the wreck of dogma, the poetic basis of religion. And it is to be remembered that under the circumstances poetry may be the purest accessible truth. In other influential quarters a similar spirit is at work. In a remarkable article published by Prof. Knight, of St. Andrews, in the September number of the *Nineteenth Century*, amid other free utterances, the following is to be found:

"If matter is not eternal, its first emergence into being is a miracle beside which all others dwindle into absolute insignificance. But, as has often been pointed out, the process is unthinkable; the sudden apocalypse of a material world out of blank nonentity cannot be imagined;[1] its emergence into order out of chaos when 'without form and void' of life, *is merely a poetic rendering of the doctrine of its slow evolution.*"

These are all bold words to be spoken before the moral philosophy class of a Scotch university, while those I have underlined show a remarkable freedom of dealing with the sacred text. They repeat in fuller language what I ventured to utter four years ago regarding the book

[1] Prof. Knight will have to reckon with the English Marriage Service, one of whose collects begins very naïvely thus: "O God, who by thy mighty power hast made all things of nothing."

of Genesis: "Profoundly interesting and indeed pathetic to me are those attempts of the opening mind of man to appease its hunger for a Cause. But the book of Genesis has no voice in scientific questions. *It is a poem, not a scientific treatise.* In the former aspect it is forever beautiful; in the latter it has been, and it will continue to be, purely obstructive and hurtful." My agreement with Prof. Knight extends still further. "Does the vital," he asks, "proceed by a still remoter development from the non-vital? Or was it created by a fiat of volition? Or"—and here he emphasizes his question—"*has it always existed in some form or other as an eternal constituent of the universe?* I do not see," he replies, "how we can escape from the last alternative." With the whole force of my conviction I say, "Nor do I;" though my mode of regarding the "eternal constituent" might differ from that of Prof. Knight.

When matter was defined by Descartes, he deliberately excluded the idea of force or motion from its attributes and from his definition. *Extension* only was taken into account. And, inasmuch as the impotence of matter to generate motion was assumed, its observed motions were referred to an external cause. God, resident outside of matter, gave the impulse. In this connection the argument in Young's "Night Thoughts" will occur to most readers:

> "Who Motion foreign to the smallest grain
> Shot through vast masses of enormous weight?
> Who bid brute Matter's restive lump assume
> Such various forms, and gave it wings to fly?"

Against this notion of Descartes the great deist John Toland, whose ashes lie unmarked in Putney Churchyard, strenuously contended. He affirmed motion to be an inherent attribute of matter—that no portion of matter was at rest, and that even the most quiescent solids were animated by a motion of their ultimate particles. It seems to me that the idea of vitality entertained in our day by Prof. Knight closely resembles the idea of motion entertained by his opponents in Toland's day. Motion was then virtually asserted to be a thing *sui generis*, distinct from matter, and incapable of being generated out of matter. Hence the obvious inference when matter was observed to move. It was the vehicle of an energy not its own—the repository of forces impressed on it from without—the purely passive recipient of the shock of the Divine. The form of logic continues, but the subject-matter is changed. "The evolution of Nature," says Prof. Knight, "may be a fact; a daily and hourly apocalypse. But we have no evidence of the non-vital passing into the vital. Spontaneous generation is, as yet, an imaginative guess, unverified by scientific tests. And matter is not itself alive. Vitality, whether seen in a single cell of protoplasm or in the human brain, is a thing *sui generis*, distinct from matter, and incapable of being generated out of matter." It may be, however, that, in pro-

cess of time, vitality will follow the example of motion, and, after the necessary antecedent wrangling, take its place among the attributes of that "universal mother" who has been so often misdefined.

That "matter is not itself alive" Prof. Knight seems to regard as an axiomatic truth. Let us place in contrast with this the notion entertained by the philosopher Ueberweg, one of the subtilest heads that Germany has produced:

> "What occurs in the brain would, in my opinion, not be possible, if the process which here appears in its greatest concentration did not obtain generally, only in a vastly diminished degree. Take a pair of mice and a cask of flour. By copious nourishment the animals increase and multiply, and in the same proportion sensations and feelings augment. The quantity of these latter possessed by the first pair is not simply diffused among their descendants, for in that case the last must feel more feebly than the first. The sensations and feelings must necessarily be referred back to the flour, where they exist, weak and pale it is true, and not concentrated as they are in the brain."[1]

We may not be able to taste or smell alcohol in a tub of fermented cherries, but by distillation we obtain from them concentrated Kirschwasser. Hence Ueberweg's comparison of the brain to a still, which concentrates the sensation and feeling, preëxisting, but diluted in the food.

"Definitions," says Mr. Holyoake,[2] "grow as the horizon of experience expands. They are not inventions, but descriptions of the state of a question. No man sees all through a discovery at once." Thus Descartes's notion of matter, and his explanation of motion, would be put aside as trivial by a physiologist or a crystallographer of the present day. They are not descriptions of the state of the question. And yet, it may be said in passing, a desire sometimes shows itself in distinguished quarters to bind us down to conceptions which passed muster in the infancy of knowledge, but which are wholly incompatible with our present enlightenment. Mr. Martineau, I think, errs when he seeks to hold me to views enunciated by "Democritus and the mathematicians." That definitions should change as knowledge advances is in accordance both with sound sense and scientific practice. When, for example, the undulatory theory was started, it was not imagined that the vibrations of light could be transverse to the direction of propagation. The example of sound was at hand, which was a case of longitudinal vibration. Now, the substitution of transverse for longitudinal vibrations in the case of light involved a radical change of conception as to the mechanical properties of the luminiferous medium. But, though this change went so far as to fill space with a substance possessing the properties of a solid, rather than those of a gas, the change was accepted, because the newly discovered facts imperatively demanded it. Following Mr. Martineau's example, the opponent of the

[1] Letter to Lange, "Geschichte des Materialismus," zweite Aufl., vol. ii., p. 521.

[2] *Nineteenth Century*, September, 1878.

undulatory theory might effectually twit the holder of it on his change of front. "This ether of yours," he might say, "alters its style with every change of service. Starting as a beggar, with scarcely a rag of 'property' to cover its bones, it turns up as a prince when large undertakings are wanted. You had some show of reason when, with the case of sound before you, you assumed your ether to be a gas in the last extremity of attenuation. But, now that new service is rendered necessary by new facts, you drop the beggar's rags, and accomplish an undertaking, great and princely enough in all conscience; for it implies that not only planets of enormous weight, but comets with hardly any weight at all, fly through your hypothetical solid without perceptible loss of motion." This would sound very cogent, but it would be very vain. Equally vain, in my opinion, is Mr. Martineau's contention that we are not justified in modifying, in accordance with advancing knowledge, our notions of matter.

Before parting from Prof. Knight, let me commend his courage as well as his insight. We have heard much of late of the peril to morality involved in the decay of religious belief. What Mr. Knight says under this head is worthy of all respect and attention:

"I admit that, were it proved that the moral faculty was derived as well as developed, its present decisions would not be invalidated. The child of experience has a father whose teachings are grave, peremptory, and august; and an earth-born rule may be as stringent as any derived from a celestial source. It does not even follow that a belief in the material origin of spiritual existence, accompanied by a corresponding decay of belief in immortality, must *necessarily* lead to a relaxation of the moral fibre of the race. It is certain that it has often done so.[1] But it is equally certain that there have been individuals, and great historical communities, in which the absence of the latter belief has neither weakened moral earnestness nor prevented devotional fervor."

I have elsewhere stated that some of the best men of my acquaintance—men lofty in thought and beneficent in act—belong to a class who assiduously let the belief referred to alone. They derive from it neither stimulus nor inspiration, while—I say it with regret—were I in quest of persons who, in regard to the finer endowments of human character, are to be ranked among the unendowed, I should find some characteristic samples among the noisier defenders of the orthodox belief. These, however, are but "hand-specimens" on both sides; the wider data referred to by Prof. Knight constitute, therefore, a welcome corroboration of my experience. Again, my excellent critic, Prof. Blackie, describes Buddha as being "a great deal more than a prophet; a rare, exceptional, and altogether transcendental incarnation of moral perfection."[2] And yet, "what Buddha preached was a gospel of pure

[1] Is this really certain? Instead of standing in the relation of cause and effect, may not the "decay" and "relaxation" be merely coexistent—both, perhaps, flowing from common historic antecedents?

[2] "Natural History of Atheism," p. 136.

human ethics, divorced not only from Brahma and the Brahmanic Trinity, but even from the existence of God." [1] These civilized and gallant voices from the North contrast pleasantly with the barbarous whoops which sometimes come to us along the same meridian—shouts of the Mohawk that ought not to be heard among the groves of Academe.

Looking backward from my present standpoint over the earnest past, a boyhood fond of play and physical action, but averse to schoolwork, lies before me. The aversion did not arise from intellectual apathy or want of appetite for knowledge, but mainly from the fact that my earliest teachers lacked the power of imparting vitality to what they taught. Athwart all play and amusement, however, a thread of seriousness ran through my character; and many a sleepless night of my childhood has been passed, fretted by the question, "Who made God?" I was well versed in Scripture; for I loved the Bible, and was prompted by that love to commit large portions of it to memory. Later on I became adroit in turning my Scriptural knowledge against the Church of Rome; but the characteristic doctrines of that Church marked only for a time the limits of inquiry. The eternal Sonship of Christ, for example, as enunciated in the Athanasian Creed, perplexed me. The resurrection of the body was also a thorn in my mind, and here I remember that a passage in Blair's "Grave" gave me momentary rest:

> ". . . . Sure the same power
> That rear'd the piece at first and took it down
> Can reassemble the loose, scatter'd parts
> And put them as they were."

The conclusion seemed for the moment entirely fair, but, with further thought, my difficulties came back to me. I had seen cows and sheep browsing upon churchyard grass, which sprang from the decaying mould of dead men. The flesh of these animals was undoubtedly a modification of human flesh, and the persons who fed upon them were as undoubtedly, in part, a more remote modification of the same substance. I figured the self-same molecules as belonging first to one body and afterward to a different one, and asked myself how two bodies so related could possibly arrange their claims at the day of resurrection. The scattered parts of each were to be reassembled and set as they were. But, if handed over to the one, how could they possibly enter into the composition of the other? Omnipotence itself, I concluded, could not reconcile the contradiction. Thus the plank which Blair's mechanical theory of the resurrection brought momentarily into sight disappeared, and I was again cast abroad on the waste ocean of speculation.

At the same time I could by no means get rid of the idea that the aspects of Nature and the consciousness of man implied the operation of a power altogether beyond my grasp—an energy the thought of

[1] "Natural History of Atheism," p. 125.

which raised the temperature of the mind, though it refused to accept shape, personal or otherwise, from the intellect. Perhaps the able critics of the *Saturday Review* are justified in speaking as they sometimes do of Mr. Carlyle. They owe him nothing, and have a right to announce the fact in their own way. I, on the other hand, owe him a great deal, and am also in honor bound to acknowledge the debt. Few, perhaps, who are privileged to come into contact with that illustrious man have shown him a sturdier front than I have, or in discussing modern science have more frequently withstood him. But I could see that his contention at bottom always was that the human soul has claims and yearnings which physical science cannot satisfy. England to come will assuredly thank him for his affirmation of the ethical and ideal side of human nature. Be this as it may, at the period now reached in my story, the feeling above referred to was indefinitely strengthened, my whole life being at the same time rendered more earnest, resolute, and laborious, by the writings of Carlyle. In this relation I cared little for political theories or philosophic systems, but I cared a great deal for the propagated life and strength of pure and powerful minds. At school I had picked up some mathematics and physics; my stock of both was, however, scanty, and I resolved to augment it. But it was really with the view of learning whether mathematics and physics could help me in other spheres, rather than with the desire of acquiring distinction in either science, that I resolved, in 1848, to break the continuity of my life, and to devote the meagre funds I had then collected to the study of science in Germany.

But science soon fascinated me on its own account; and I could see that, to carry it duly and honestly out, moral qualities were incessantly invoked. There was no room allowed for insincerity—no room even for carelessness. The edifice of science had been raised by men who had unswervingly followed the truth as it is in Nature; and in doing so had often sacrificed interests which are usually potent in this world. Among these rationalistic men of Germany conscientiousness in work was as much insisted on as it could be among theologians. And why, since they had not the rewards or penalties of the theologian to offer to their disciples? Because they assumed, and were justified in assuming, that those whom they addressed had that within them which would respond to their appeal. If Germany should ever change for something less noble the simple earnestness and fidelity to duty which in those days characterized her teachers, and through them her sons generally, it will not be because of rationalism. Such a decadent Germany might coexist with the most rampant rationalism without their standing to each other in the relation of cause and effect.

My first really laborious investigation landed me in a region which harmonized with my speculative tastes. It was essentially an inquiry in molecular physics, having reference to the curious, and then perplexing, phenomena exhibited by crystals when freely suspended in the

magnetic field. I here lived amid the most complex operations of magnetism in its twofold aspect of an attractive and a repellent force. Iron was attracted by a magnet, bismuth was repelled, and the crystals operated on ranged themselves under these two heads. Faraday and Plücker had worked assiduously at the subject, and had invoked the aid of new forces to account for the phenomena. It was soon, however, found that the displacement, in a crystal, of an atom of the iron class by an atom of the bismuth class, without any change of crystalline form, produced a complete reversal of the phenomena. The lines through the crystal which were in the one case drawn toward the poles of the magnet, were driven in the other case from these poles. By such instances and the reasoning which they suggested, magne-crystallic action was proved to be due, not to the operation of new forces, but to the modification of the old ones by molecular arrangement. Whether diamagnetism, like magnetism, was a polar force, was in those days a subject of the most lively contention. It was finally proved to be so; and the most complicated cases of magne-crystallic action were immediately shown to be simple mechanical consequences of the principle of diamagnetic polarity. These early researches, which occupied in all five years of my life, and during which the molecular architecture of crystals was an incessant subject of mental contemplation, gave a tinge and bias to my subsequent scientific thought, and their influence is easily traced in my subsequent inquiries. For example, during nine long years of labor on the subject of radiation, heat and light were handled throughout by me, not as ends, but as instruments by the aid of which the mind might perchance lay hold upon the ultimate particles of matter.

Scientific progress depends on two factors which incessantly interact —the strengthening of the mind by exercise and the illumination of phenomena by knowledge. There seems no limit to the insight regarding physical processes which this interaction carries in its train. Through such insight we are enabled to enter and explore that subsensible world into which all natural phenomena strike their roots, and from which they derive nutrition. By it we are enabled to place before the mind's eye atoms and atomic motions which lie far beyond the range of the senses, and to apply to them reasoning as stringent as that applied by the mechanician to the motions and collisions of sensible masses. But, once committed to such conceptions, there is the risk of being led irresistibly beyond the bounds of inorganic Nature. Even in these early stages of scientific development I found myself more and more compelled to regard not only crystals, but organic structures, the body of man inclusive, as cases of molecular architecture, infinitely more complex, it is true, than those of inorganic Nature, but reducible, in the long-run, to the same mechanical laws. In ancient journals I find recorded ponderings and speculations relating to these subjects, and attempts made, by reference to magnetic and crystalline phenomena, to present some satisfactory image to the mind of the way in which plants and animals are

built up. Perhaps I may be excused for noting a sample of these early speculations, already possibly known to a few of my readers, but which here finds a more suitable place than that which it formerly occupied.

Sitting, in the summer of 1855, with my friend Dr. Debus under the shadow of a massive elm on the bank of a river in Normandy, the current of our thoughts and conversation was substantially this: We regarded the tree above us. In opposition to gravity its molecules had ascended, diverged into branches, and budded into innumerable leaves. What caused them to do so—a power external to themselves, or an inherent force? Science rejects the outside builder; let us, therefore, consider from the other point of view the experience of the present year. A low temperature had kept back for weeks the life of the vegetable world. But at length the sun gained power—or, rather, the cloud-screen which our atmosphere had drawn between him and us was removed—and life immediately kindled under his warmth. But what is life, and how can solar light and heat thus affect it? Near our elm was a silver-birch, with its leaves rapidly quivering in the morning air. We had here motion, but not the motion of life. Each leaf moved as a mass under the influence of an outside force, while the motion of life was inherent and molecular. How are we to figure this molecular motion—the forces which it implies, and the results which flow from them? Suppose the leaves to be shaken from the birch-tree and enabled to attract and repel each other. To fix the ideas, suppose the point of each leaf to repel all other points and to attract the other ends, and the root of each leaf to repel all other roots, but to attract the points. The leaves would then resemble an assemblage of little magnets abandoned freely to the interaction of their own forces. In obedience to these they would arrange themselves, and finally assume positions of rest, forming a coherent mass. Let us suppose the breeze, which now causes them to quiver, to disturb the assumed equilibrium. As often as disturbed there would be a constant effort on the part of the leaves to reestablish it; and in making this effort the mass of leaves would pass through different shapes and forms. If other leaves, moreover, were at hand endowed with similar forces, the action would extend to them —a growth of the mass of leaves being the consequence.

We have strong reason for assuming that the ultimate particles of matter—the atoms and molecules of which it is made up—are endowed with forces coarsely typified by those here ascribed to the leaves. The phenomena of crystallization lead, of necessity, to this conception of molecular polarity. Under the operation of such forces the molecules of a seed, like our fallen leaves in the first instance, take up positions from which they would never move if undisturbed by an external impulse. But solar light and heat, which come to us as waves through space, are the great agents of molecular disturbance. On the inert molecules of seed and soil these waves impinge, disturbing the atomic

equilibrium, which there is an immediate effort to restore. The effort, incessantly defeated—for the waves continue to pour in—is incessantly renewed; in the molecular struggle, matter is gathered from the soil and from the atmosphere, and built, in obedience to the forces which guide the molecules, into the special form of the tree. In a general way, therefore, the life of the tree might be defined as an unceasing effort to restore a disturbed equilibrium. In the building of crystals, Nature makes her first structural effort; we have here the earliest groping of the so-called "vital force," and the manifestations of this force in plants and animals, though, as already stated, indefinitely more complex, are to be regarded of the same mechanical quality as those concerned in the building of the crystal.

Consider the cycle of operations by which the seed produces the plant, the plant the flower, the flower again the seed, the causal line returning with the fidelity of a planetary orbit to its original point of departure. Who or what planned this molecular rhythm? We do not know—science fails even to inform us whether it was ever "planned" at all. Yonder butterfly has a spot of orange on its wing; and if we look at a drawing made a century ago, of one of the ancestors of that butterfly, we probably find the self-same spot upon the wing. For a century the molecules have described their cycles. Butterflies have been begotten, have been born, and have died; still we find the molecular architecture reproduced. Who or what determined this persistency of recurrence? We do not know; but we stand within our intellectual range when we say that there is probably nothing in that wing which may not yet find its Newton to prove that the principles involved in its construction are qualitatively the same as those brought into play in the formation of the solar system. We may even take a step further, and affirm that the brain of man—the organ of his reason and his sense—without which he can neither think nor feel—is also an assemblage of molecules, acting and reacting according to law. Here, however, the methods pursued in mechanical science come to an end; and if asked to deduce from the physical interaction of the brain-molecules the least of the phenomena of sensation or thought, we must acknowledge our helplessness. The association of both with the matter of the brain may be as certain as the association of light with the rising of the sun. But whereas in the latter case we have unbroken mechanical connection between the sun and our organs, in the former case logical continuity disappears. Between molecular mechanics and consciousness is interposed a fissure, over which the ladder of physical reasoning is incompetent to carry us. We must, therefore, accept the observed association as an empirical fact, without being able to bring it under the yoke of *a priori* deduction.

Such were the ponderings which ran habitually through my mind in the days of my scientific youth. They illustrate two things: a determi-

nation to push physical considerations to their utmost legitimate limit; and an acknowledgment that physical considerations do not lead to the final explanation of all that we feel and know. This acknowledgment, be it said in passing, was by no means made with the view of providing room for the play of considerations other than physical. The same intellectual duality, if I may use the phrase, manifests itself in the following extract from an article published in the *Saturday Review* for August 4, 1860:

"The philosophy of the future will assuredly take more account than that of the past of the dependence of thought and feeling on physical processes; and it may be that the qualities of the mind will be studied through organic combinations as we now study the character of a force through the affections of ordinary matter. We believe that every thought and every feeling has its definite mechanical correlative—that it is accompanied by a certain breaking up and remarshaling of the atoms of the brain. This latter process is purely physical; and, were the faculties we now possess sufficiently expanded, without the creation of any new faculty, it would doubtless be within the range of our augmented powers to infer from the molecular state of the brain the character of the thought acting on it, and conversely to infer from the thought the exact molecular condition of the brain. We do not say—and this, as will be seen, is all-important—that the inference here referred to would be an *a priori* one. But by observing, with the faculties we assume, the state of the brain, and the associated mental affections, both might be so tabulated side by side that, if one were given, a mere reference to the table would declare the other. Our present powers, it is true, shrivel into nothingness when brought to bear on such a problem, but it is because of its complexity and our limits that this is the case. The *quality* of the problem and of our powers are, we believe, so related that a mere expansion of the latter would enable them to cope with the former. Why, then, in scientific speculation should we turn our eyes exclusively to the past? May it not be that a time is coming—ages no doubt distant, but still advancing—when the dwellers upon this earth, starting from the gross human brain of to-day as a rudiment, may be able to apply to these mighty questions faculties of commensurate extent? Given the requisite expansibility to the present senses and intelligence of man—given also the time necessary for their expansion—and this high goal may be attained. Development is all that is required, and not a change of quality. There need be no absolute breach of continuity between us and our loftier brothers yet to come.

"We have guarded ourselves against saying that the inferring of thought from material combinations and arrangements would be an inference *a priori*. The inference meant would be the same in kind as that which the observation of the effects of food and drink upon the mind would enable us to make, differing only from the latter in the degree of analytical insight which we suppose attained. Given the masses and distances of the planets, we can infer the perturbations consequent on their mutual attractions. Given the nature of a disturbance in water, air, or ether—knowing the physical qualities of the medium—we can infer how its particles will be affected. In all this we deal with physical laws. The mind runs with certainty along the line of thoughts which connect the phenomena, and from beginning to end there is no break in the chain. But when we endeavor to pass by a similar process from the phenomena of physics to those of thought, we meet a problem which transcends any conceiv-

able expansion of the powers which we now possess. We may think over the subject again and again, but it eludes all intellectual presentation. The territory of physics is wide, but it has its limits from which we look with vacant gaze into the region beyond. Let us follow matter to its utmost bounds, let us claim it in all its forms—even in the muscles, blood, and brain of man himself, it is ours to experiment with and to speculate upon. Casting the term 'vital force' from our vocabulary, let us reduce, if we can, the visible phenomena of life to mechanical attractions and repulsions. Having thus exhausted physics, and reached its very rim, a mighty mystery still looms beyond us. We have, in fact, made no step toward its solution. And thus it will ever loom, compelling the philosophies of successive ages to confess that—

> . . . . 'we are such stuff
> As dreams are made of, and our little life
> Is rounded by a sleep.'"

In my work on "Heat," first published in 1863, I employ the precise language here extracted from the *Saturday Review*.

In this extract a distinction is revealed which I had resolved at all hazards to draw—that, namely, between what men knew or might know, and what they could never hope to know. Impart simple magnifying power to our present vision, and the atomic motions of the brain itself might be brought into view. Compare these motions with the corresponding states of consciousness, and an empirical nexus might be established; but "we try to soar in a vacuum when we endeavor to pass by logical deduction from the one to the other." Among those brain-effects a new product appears which defies mechanical treatment. We cannot deduce consciousness from motion, or motion from consciousness, as we deduce one motion from another. Nevertheless observation is open to us, and by it relations may be established which are at least as valid as the conclusions of deductive reason. The difficulty may really lie in the attempt to convert a datum into an inference—an ultimate fact into a product of logic. My desire for the moment, however, is, not to theorize, but to let fact speak in reply to accusation.

The most "materialistic" speculation for which I am responsible, prior to the "Belfast Address," is embodied in the following extract from a brief article written as far back as 1865:

> "Supposing the molecules of the human body, instead of replacing others, and thus renewing a preëxisting form, to be gathered first-hand from Nature, and placed in the exact relative positions which they occupy in the body. Supposing them to have the same forces and distribution of forces, the same motions and distribution of motions—would this organized concourse of molecules stand before us as a sentient, thinking being? There seems no valid reason to assume that it would not. Or, supposing a planet carved from the sun set spinning round an axis, and sent revolving round the sun at a distance equal to that of our earth, would one consequence of the refrigeration of the mass be the development of organic forms? I lean to the affirmative."

This may be plain speaking, but it is without "dogmatism." An opinion is expressed, a belief, a *leaning*—not an established "doctrine."

The burden of my writings in this connection is as much a recognition of the weakness of science as an assertion of its strength. In 1867 I told the working-men of Dundee that while making the largest demand for freedom of investigation; while considering science to be alike powerful as an instrument of intellectual culture, and as a ministrant to the material wants of men—if asked whether science has solved, or is likely in our day to solve, "the problem of the universe," I must shake my head in doubt. I compare the mind of man to a musical instrument with a certain range of notes, beyond which in both directions exists infinite silence. The phenomena of matter and force come within our intellectual range; but behind, and above, and around us, the real mystery of the universe lies unsolved, and, as far as we are concerned, is incapable of solution.

While refreshing my mind on these old themes I am struck by the poverty of my own thought; appearing to myself as a person possessing one idea, which so overmasters him that he is never weary of repeating it. That idea is the polar conception of the grandeur and the littleness of man—the vastness of his range in some respects and directions, and his powerlessness to take a single step in others. In 1868, before the mathematical and physical section of the British Association, then assembled at Norwich, I repeat the same well-worn note:

"In affirming the growth of the human body to be mechanical, and thought as exercised by us to have its correlative in the physics of the brain, the position of the 'materialist,' as far as that position is tenable, is stated. I think the materialist will be able finally to maintain this position against all attacks, but I do not think he can pass beyond it. The problem of the connection of body and soul is as insoluble in its modern form as it was in the prescientific ages. Phosphorus is a constituent of the human brain, and a trenchant German writer has exclaimed, 'Ohne Phospor kein Gedanke!' That may or may not be the case; but, even if we knew it to be the case, the knowledge would not lighten our darkness. On both sides of the zone here assigned to the materialist, he is equally helpless. If you ask him whence is this 'matter,' of which we have been discoursing—who or what divided it into molecules, and impressed upon them this necessity of running into organic forms—he has no answer. Science is also mute in regard to such questions. But if the materialist is confounded, and Science is rendered dumb, who else is prepared with an answer? Let us lower our heads and acknowledge our ignorance, priest and philosopher, one and all."

The roll of echoes which succeeded the lecture delivered by Prof. Virchow at Munich on September 22, 1877, was long and loud. The *Times* published a nearly full translation of the lecture, and it was eagerly commented on in other journals. Glances from it to an address delivered by me before the Midland Institute last autumn were very frequent. Prof. Virchow was held up to me in some quarters as a model of philosophic caution, who by his reasonableness reproved my rashness and by his depth reproved my shallowness. With true theologic courtesy I was sedulously emptied not only of "the principles of

scientific thought," but of "common modesty" and "common sense." And, though I am indebted to Prof. Clifford for recalling in the *Nineteenth Century* for April the public mind in this connection from heated fancy to sober fact, I do not think a brief additional examination of Virchow's views, and of my relation to them, will be out of place here.

The key-note of his position is struck in the preface to the excellent English translation of his lecture—a preface written expressly by himself. Nothing, he says, was further from his intention than any wish to disparage the great services rendered by Mr. Darwin to the advancement of biological science, of which no one has expressed more admiration than himself. On the other hand, it seemed high time to him to enter an energetic protest against the attempts that are made to proclaim the problems of research as actual facts, and the opinions of scientists as established science. On the ground, among others, that it promotes the pernicious delusions of the socialists, Virchow considers the theory of evolution dangerous; but his fidelity to truth is so great that he would brave the danger and teach the theory, if it were only proved. The burden indeed of this celebrated lecture is a warning that a marked distinction ought to be made between that which is experimentally established, and that which is still in the region of speculation. As to the latter, Virchow by no means imposes silence. He is far too sagacious a man to commit himself, at the present time of day, to any such absurdity. But he insists that it ought not to be put on the same evidential level as the former. "It ought," as he poetically expresses it, "to be written in small letters under the text." The audience ought to be warned that the speculative matter is only *possible*, not *actual* truth—that it belongs to the region of "belief," and not to that of demonstration. As long as a problem continues in this speculative stage it would be mischievous, he considers, to teach it in our schools. "We ought not," he urges, "to represent our conjecture as a certainty, nor our hypothesis as a doctrine: this is inadmissible." With regard to the connection between physical processes and mental phenomena he says: "I will, indeed, willingly grant that we can find certain gradations, certain definite points at which we trace a passage from mental processes to processes purely physical, or of a physical character. Throughout this discourse I am not asserting that it will never be possible to bring psychical processes into an immediate connection with those that are physical. All I say is, that we have *at present* no right to set up this *possible* connection as a doctrine of science." In the next paragraph he reiterates his position with reference to the introduction of such topics into school-teaching. "We must draw," he says, "a strict distinction between what we wish to *teach* and what we wish to *search for*. The objects of our research are expressed as problems (or hypotheses). *We need not keep them to ourselves; we are ready to communicate them to all the world*, and say, 'There is the problem; that is what we strive for.' . . . The investigation of such problems,

in which the whole nation may be interested, cannot be restricted to any one. This is freedom of inquiry. But the problem (or hypothesis) is not, without further debate, to be made *a doctrine*." He will not concede to Dr. Haeckel "that it is a question for the schoolmasters to decide, whether the Darwinian theory of man's descent should be at once laid down as the basis of instruction, and the protoplastic soul be assumed as the foundation of all ideas concerning spiritual being." The professor concludes his lecture thus: "With perfect truth did Bacon say of old, '*Scientia est potentia*.' But he also defined that knowledge; and the knowledge he meant was not speculative knowledge, not the knowledge of hypotheses, but it was objective and actual knowledge. Gentlemen, I think we should be abusing our power, we should be imperiling our power, unless in our teaching we restrict ourselves to this perfectly safe and unassailable domain. From this domain *we may make incursions into the field of problems*, and I am sure that every venture of that kind will then find all needful security and support." I have emphasized by italics two sentences in the foregoing series of quotations; the other italics are the author's own.

Virchow's position could not be made clearer by any comments of mine than he has here made it himself. That position is one of the highest practical importance. "Throughout our whole German Fatherland," he says, "men are busied in renovating, extending, and developing the system of education, and in inventing fixed forms in which to mould it. On the threshold of coming events stands the Prussian law of education. In all the German states larger schools are being built, new educational establishments are set up, the universities are extended, 'higher' and 'middle' schools are founded. Finally comes the question, 'What is to be the chief substance of the teaching?'" What, in regard to science, Virchow thinks it ought and ought not to be, is disclosed by the foregoing quotations. There ought to be a clear distinction made between science in the state of hypothesis and science in the state of fact. From school-teaching the former ought to be excluded. And, inasmuch as it is still in its hypothetical stage, the ban of exclusion ought to fall upon the theory of evolution.

I now freely offer myself for judgment before the tribunal whose law is here laid down. First and foremost, then, I have never advocated the introduction of the theory of evolution into our schools. I should even be disposed to resist its introduction before its meaning had been better understood and its utility more fully recognized than it is now by the great body of the community. The theory ought, I think, to bide its time until the free conflict of discovery, argument, and opinion, has won for it this recognition. In dealing with the community great changes must have *timeliness* as well as truth upon their side. But, if the mouths of thinkers are stopped, the necessary social preparation will be impossible; an unwholesome divorce will be estab-

lished between the expert and the public, and the slow and natural process of leavening the social lump by discovery and discussion will be displaced by something far less safe and salutary. On this count, then, I claim acquittal, being for the moment on the side of Virchow.

In a discourse delivered before the British Association at Liverpool, after speaking of the theory of evolution applied to the primitive condition of matter as belonging to "the dim twilight of conjecture," and affirming that "the certainty of experimental inquiry is here shut out," I sketch the nebular theory as enunciated by Kant and Laplace, and afterward proceed thus:

"Accepting some such view of the construction of our system as *probable*, a desire immediately arises to connect the present life of our planet with the past. We wish to know something of our remotest ancestry. On its first detachment from the sun, life, as we understand it, could not have been present on the earth. How, then, did it come there? The thing to be encouraged here is a reverent freedom—a freedom preceded by the hard discipline which checks licentiousness in speculation—while the thing to be repressed, both in science and out of it, is dogmatism. And here I am in the hands of the meeting, willing to end but ready to go on. *I have no right to intrude upon you unasked the unformed notions which are floating like clouds or gathering to more solid consistency in the modern speculative mind.*"

I then notice more especially the theory of evolution:

"Those who hold the doctrine of evolution *are by no means ignorant of the uncertainty of their data, and they only yield to it a provisional assent.* They regard the nebular hypothesis as probable; and, in the utter absence of any proof of the illegality of the act, they prolong the method of Nature from the present into the past. Here the observed uniformity of Nature is their only guide. Having determined the elements of their curve in a world of observation and experiment, they prolong that curve into an antecedent world, and accept as probable the unbroken sequence of development from the nebula to the present time."

Thus it appears that, long antecedent to the publication of his advice, I did exactly what Prof. Virchow recommends, showing myself as careful as he could be not to claim for a scientific doctrine a certainty which did not belong to it.

I now pass on to the "Belfast Address," and will cite at once from it the passage which has given rise to the most violent animadversion:

"Believing as I do in the continuity of Nature, I cannot stop abruptly where our microscopes cease to be of use. At this point the vision of the mind authoritatively supplements that of the eye. By an intellectual necessity I cross the boundary of the experimental evidence, and discern in that 'matter' which we, in our ignorance of its latent powers, and notwithstanding our professed reverence for its Creator, have hitherto covered with opprobrium, the promise and potency of all terrestrial life."

Without halting for a moment I go on to do the precise thing which Prof. Virchow declares to be necessary:

"If you ask me whether there exists the least evidence to prove that any form of life can be developed out of matter independently of antecedent life, my reply is that evidence considered perfectly conclusive by many has been adduced, and that were we to follow a common example, and accept testimony because it falls in with our belief, we should eagerly close with the evidence referred to. But those to whom I refer as having studied this question, believing the evidence offered in favor of 'spontaneous generation' to be vitiated by error, cannot accept it. They know full well that the chemist now prepares from inorganic matter a vast array of substances, which were some time ago regarded as the products solely of vitality. They are intimately acquainted with the structural power of matter, as evidenced in the phenomena of crystallization. They can justify scientifically their *belief* in its potency, under the proper conditions, to produce organisms. But, in reply to your question, they will frankly admit their inability to point to any satisfactory experimental proof that life can be developed, save from demonstrable antecedent life."[1]

Three years subsequently it fell to my lot to address the members of the Midland Institute at Birmingham, and a very few words will reveal the grounds of my reference on that occasion to the "Theory of Descent." "Ten years have elapsed," said Dr. Hooker at Norwich in 1868,[2] "since the publication of 'The Origin of Species by Natural Selection,' and it is therefore not too early now to ask what progress that bold theory has made in scientific estimation. Since the 'Origin' appeared it has passed through four English editions,[3] two American, two German, two French, several Russian, a Dutch, and an Italian. So far from Natural Selection being a thing of the past (the *Athenæum* had stated it to be so), it is an accepted doctrine with almost every philosophical naturalist, including, it will always be understood, a considerable proportion who are not prepared to admit that it accounts for all Mr. Darwin assigns to it." In the following year, at Innspruck, Helmholtz took up the same ground. Another decade has now passed, and he is simply blind who cannot see the enormous progress made by the theory during that time. Some of the outward and visible signs of this advance are readily indicated. The hostility and fear which so long prevented the recognition of Mr. Darwin by his own university have vanished, and this year Cambridge, amid universal acclamation, conferred on him her Doctor's degree. The Academy of Sciences in Paris, which had so long persistently closed its doors against him, has also yielded at last; while sermons, lectures, and published articles, plainly show that even the clergy have, to a great extent, become acclimatized to the Darwinian air. My reference to Mr. Darwin in the Birmingham Address was based upon the knowledge that such changes had been accomplished, and were still going on.

That the lecture of Prof. Virchow can to any practical extent dis-

[1] Quoted by Clifford, *Nineteenth Century*, iii., p. 726.

[2] President's Address to the British Association.

[3] Published by Mr. John Murray, the English publisher of Virchow's lecture. Bane and antidote are thus impartially distributed by the same hand.

turb this progress of public faith in the theory of evolution, I do not believe. That the special lessons of caution which he inculcates were exemplified by me, years before his voice was heard upon this subject, has been proved in the foregoing pages. It is possible to draw the coincident lines still further, for most of what he has said about spontaneous generation might have been uttered by me. I share his opinion that the theory of evolution in its complete form involves the assumption that at some period or other of the earth's history there occurred what would be now called "spontaneous generation." I agree with him that "the proofs of it are still wanting. . . . Whoever," he says, "recalls to mind the lamentable failure of all the attempts made very recently to discover a decided support for the *generatio æquivoca* in the lower forms of transition from the inorganic to the organic world will feel it doubly serious to demand that this theory, so utterly discredited, should be in any way accepted as the basis of all our views of life." I hold with Virchow that the failures *have* been lamentable, that the doctrine *is* utterly discredited. But my position here is so well known that I need not dwell upon it further.

With one special utterance of Prof. Virchow his translator connects me by name. "I have no objection," observes the professor, "to your saying that atoms of carbon also possess mind, or that in their connection with the Plastidule company they acquire mind; only *I do not know how I am to perceive this.*" This is substantially what I had said seventeen years previously in the *Saturday Review*. The professor continues: "If I explain attraction and repulsion as exhibitions of mind, as psychical phenomena, I simply throw the Psyche out of the window, and the Psyche ceases to be a Psyche." I may say, in passing, that the Psyche that *could* be cast out of the window is not worth house-room. At this point the translator, who is evidently a man of culture, strikes in with a foot-note: "As an illustration of Prof. Virchow's meaning, we may quote the conclusion at which Dr. Tyndall arrives respecting the hypothesis of a human soul, offered as an explanation or a simplification of a series of obscure phenomena—psychical phenomena, as he calls them. 'If you are content to make your soul a poetic rendering of a phenomenon which refuses the yoke of ordinary physical laws, I, for one, would not object to this exercise of ideality.'"[1] Prof. Virchow's meaning, I admit, required illustration; but I do not clearly see how the quotation from me subserves this purpose. I do not even know whether I am cited as meriting praise or deserving opprobrium. In a far coarser fashion this utterance of mine has been dealt with in another place: it may therefore be worth while to spend a few words upon it.

The sting of a wasp at the finger-end announces itself to the brain as pain. The impression made by the sting travels, in the first place,

[1] Presidential Address delivered before the Birmingham and Midland Institute, October 1, 1877. *Fortnightly Review*, November 1, 1877, p. 607.

with comparative slowness along the nerves affected; and only when it reaches the brain have we the fact of consciousness. Those who think most profoundly on this subject hold that a chemical change, which, strictly interpreted, is atomic motion, is, in such a case, propagated along the nerve, and communicated to the brain. Again, on feeling the sting I flap the insect violently away. What has caused this motion of my hand? The command to remove the insect travels from the brain along the motor nerves to the proper muscles, and, their force being unlocked, they perform the work demanded of them. But what moved the nerve-molecules which unlocked the muscle? The sense of pain, it may be replied. But how can a sense of pain, or any other state of consciousness, make matter move? Not all the sense of pain or pleasure in the world could lift a stone or move a billiard-ball; why should it stir a molecule? Try to express the motion numerically in terms of the sensation, and the difficulty immediately appears. Hence the idea long ago entertained by philosophers, but lately brought into special prominence, that the physical processes are complete in themselves, and would go on just as they do if consciousness were not at all implicated. Consciousness, on this view, is a kind of by-product inexpressible in terms of force and motion, and unessential to the molecular changes going on in the brain.

Four years ago I wrote thus:

"Do states of consciousness enter as links into the chain of antecedence and sequence which gives rise to bodily actions? Speaking for myself, it is certain that I have no power of imagining such states interposed between the molecules of the brain, and influencing the transference of motion among the molecules. The thing 'eludes all mental presentation.' Hence an iron strength seems to belong to the logic which claims for the brain an automatic action uninfluenced by consciousness. But it is, I believe, admitted, by those who hold the automaton theory, that consciousness is *produced* by the motion of the molecules of the brain; and this production of consciousness by molecular motion is to me quite as unpresentable to the mental vision as the production of molecular motion by consciousness. If I reject one result I must reject both. *I, however, reject neither*, and thus stand in the presence of two incomprehensibles instead of one incomprehensible."

Here I secede from the automaton theory, though maintained by friends who have all my esteem, and fall back upon the avowal which occurs with such wearisome iteration throughout the foregoing pages; namely, my own utter incapacity to grasp the problem.

This avowal is repeated with emphasis in the passage to which Prof. Virchow's translator draws attention. What, I there ask, is the causal connection between the objective and the subjective—between molecular motions and states of consciousness? My answer is: I do not see the connection, nor am I acquainted with anybody who does. It is no explanation to say that the objective and subjective are two sides of one and the same phenomenon. Why should the phenomenon

have two sides? This is the very core of the difficulty. There are plenty of molecular motions which do not exhibit this two-sideness. Does water think or feel when it runs into frost-ferns upon a window-pane? If not, why should the molecular motion of the brain be yoked to this mysterious companion—consciousness? We can form a coherent picture of all the purely physical processes—the stirring of the brain, the thrilling of the nerves, the discharging of the muscles, and all the subsequent motions of the organism. We are here dealing with mechanical problems which are mentally presentable. But we can form no picture of the process whereby consciousness emerges either as a necessary link or as an accidental by-product of this series of actions. The reverse process of the production of motion by consciousness is equally unpresentable to the mind. We are here, in fact, on the boundary-line of the intellect, where the ordinary canons of science fail to extricate us from difficulty. If we are true to these canons, we must deny to subjective phenomena all influence on physical processes. The mechanical philosopher, *as such*, will never place a state of consciousness and a group of molecules in the relation of mover and moved. Observation proves them to interact; but, in passing from the one to the other, we meet a blank which the logic of deduction is unable to fill. This, the reader will remember, is the conclusion at which I had arrived more than twenty years ago. I lay bare unsparingly the central difficulty of the materialist, and tell him that the facts of observation which he considers so simple are "almost as difficult to be seized mentally as the idea of a soul." I go further, and say, in effect, to those who wish to retain this idea, "If you abandon the interpretations of grosser minds, who image the soul as a Psyche which could be thrown out of the window—an entity which is usually occupied, we know not how, among the molecules of the brain, but which on due occasion, such as the intrusion of a bullet or the blow of a club, can fly away into other regions of space—if, abandoning this heathen notion, you approach the subject in the only way in which approach is possible—if you consent to make your soul a poetic rendering of a phenomenon which, as I have taken more pains than anybody else to show you, refuses the yoke of ordinary physical laws—then I, for one, would not object to this exercise of ideality." I say it strongly, but with good temper, that the theologian, or the defender of theology, who hacks and scourges me for putting the question in this light is guilty of black ingratitude.

Notwithstanding the agreement thus far pointed out, there are certain points in Prof. Virchow's lecture to which I should feel inclined to take exception. I think it was hardly necessary to associate the theory of evolution with socialism; it may be even questioned whether it was correct to do so. As Lange remarks, the aim of socialism, or of its extreme leaders, is to overthrow the existing systems of government,

and anything that helps them to this end is welcomed, whether it be atheism or papal infallibility. For long years the Socialists saw church and state united against them, and both were therefore regarded with a common hatred. But no sooner does a serious difference arise between church and state, than a portion of the Socialists begin immediately to dally with the former.[1] The experience of the last German elections illustrates Lange's position. Far nobler and truer to my mind than this fear of promoting socialism by a scientific theory which the best and soberest heads in the world have substantially accepted, is the position assumed by Helmholtz, who in his "Popular Lectures" describes Darwin's theory as embracing "an essentially new creative thought" (einen wesentlich neuen schöpferischen Gedanken), and who illustrates the greatness of this thought by copious references to the solutions, previously undreamed of, which it offers of the enigmas of life and organization. One point in this "popular" exposition deserves especial mention here. Helmholtz refers to the dominant position acquired by Germany in physiology and medicine, while other nations have kept abreast of her in the investigation of inorganic Nature. He claims for German men the credit of pursuing with unflagging zeal and self-denying industry, guided by ideal aims, and without any immediate prospect of practical utility, the cultivation of pure science. But that which has determined German superiority in the fields referred to was, in his opinion, something different from this. Inquiries as to the nature of life are intimately connected with psychological and ethical questions; and he claims for his countrymen a greater fearlessness of the consequences which a full knowledge of the truth may here carry along with it than reigns among the inquirers of other nations. Helmholtz points to the cause of this timidity:

"England and France possess distinguished investigators—men competent to follow up and illustrate with vigorous energy the methods of natural science; but they have hitherto been compelled to bend before social and theological prejudices, and could only utter their convictions under the penalty of injuring their social influence and usefulness. Germany has gone forward more courageously. She has cherished the trust, which has never been deceived, that complete truth carries with it the antidote against the bane and danger which follow in the train of half-knowledge. A cheerfully laborious and temperate people—a people morally strong—can well afford to look truth full in the face. Nor are they to be ruined by the enunciation of one-sided theories, even when these may appear to threaten the bases of society."

These words of Helmholtz are, in my opinion, wiser and more applicable to the condition of Germany at the present moment than those which express the fears of Prof. Virchow. It will be remembered that at the time of his lecture his chief anxiety was directed toward France; but France has since that time given ample evidence of her ability to

[1] "Geschichte des Materialismus," zweite Aufl., vol. ii., p. 538.

crush, not only Socialists, but anti-Socialists, who would impose on her a yoke which she refuses to bear.

In close connection with these utterances of Helmholtz, I place another utterance not less noble, which I trust was understood and appreciated by those to whom it was addressed:

"If" (said the President of the British Association in his opening address in Dublin) "we could lay down beforehand the precise limits of possible knowledge, the problem of physical science would be already half solved. But the question to which the scientific explorer has often to address himself is not merely whether he is able to solve this or that problem, but whether he can so far unravel the tangled threads of the matter with which he has to deal as to weave them into a definite problem at all. . . . If his eye seem dim, he must look steadfastly and with hope into the misty vision, until the very clouds wreath themselves into definite forms. If his ear seem dull, he must listen patiently and with sympathetic trust to the intricate whisperings of Nature—the goddess, as she has been called, of a hundred voices—until here and there he can pick out a few simple notes to which his own powers can resound. If, then, at a moment when he finds himself placed on a pinnacle from which he is called upon to take a perspective survey of the range of science, and to tell us what he can see from his vantage-ground; if at such a moment, after straining his gaze to the very verge of the horizon, and after describing the most distant of well-defined objects, he should give utterance also to some of the subjective impressions which he is conscious of receiving from regions beyond; if he should depict possibilities which seem opening to his view; if he should explain why he thinks this a mere blind alley and that an open path—*then the fault and the loss would be alike ours if we refused to listen calmly, and temperately to form our own judgment on what we hear; then assuredly it is we who would be committing the error of confounding matters of fact with matters of opinion, if we failed to discriminate between the various elements contained in such a discourse, and assumed that they had been all put on the same footing.*"

While largely agreeing with him, I cannot quite accept the setting in which Prof. Virchow places the confessedly abortive attempts to secure an experimental basis for the doctrine of spontaneous generation. It is not a doctrine "so discredited" that some of the scientific thinkers of England accept "as the basis of all their views of life." Their induction is by no means thus limited. They have on their side more than the "reasonable probability" deemed sufficient by Bishop Butler for practical guidance in the gravest affairs, that the members of the solar system which are now discrete once formed a continuous mass; that in the course of untold ages, during which the work of condensation went on through the waste of heat in space, the planets were detached; and that our present sun is the residual nucleus of the flocculent or gaseous ball from which the planets were successively separated. Life, as we define it, was not possible for æons subsequent to this separation. When and how did it appear? I have already pressed this question, but have received no answer.[1] If, with Prof. Knight, we

[1] In the "Apology for the Belfast Address," the question is reasoned out.

regard the Bible account of the introduction of life upon the earth as a poem, not as a statement of fact, where are we to seek for guidance as to the fact? There does not exist a barrier possessing the strength of a cobweb to oppose to the hypothesis which ascribes the appearance of life to that "potency of matter" which results in natural evolution.[1] This hypothesis is not without its difficulties, but they vanish when compared with those which encumber its rivals. There are various facts in science obviously connected, and whose connections we are unable to trace; but we do not think of filling the gap between them by the intrusion of a separable spiritual agent. In like manner, though we are unable to trace the course of things from the nebula, where there was no life in our sense, to the present earth where life abounds, the spirit and practice of science pronounce against the intrusion of an anthropomorphic creator. Theologians must liberate and refine their conceptions or be prepared for the rejection of them by thoughtful minds. It is they, not we, who lay claim to knowledge never given to man. "Our refusal of the creative hypothesis is less an assertion of knowledge than a protest against the assumption of knowledge which must long, if not always, lie beyond us, and the claim to which is a source of perpetual confusion." At the same time, when I look with strenuous gaze into the whole problem as far as my capacities allow, overwhelming wonder is the predominant feeling. This wonder has come to me from the ages just as much as my understanding, and it has an equal right to satisfaction. Hence I say, if, abandoning your illegitimate claim to knowledge, you place, with Job, your forehead in the dust and acknowledge the authorship of this universe to be past finding out —if, having made this confession, and relinquished the views of the mechanical theologian, you desire, for the satisfaction of feelings which I admit to be in great part those of humanity at large, to give ideal form to the Power that moves all things—it is not by me that you will find objections raised to this exercise of ideality, when consciously and worthily carried out.

Again, I think Prof. Virchow's position, in regard to the question of *contagium animatum*, is not altogether that of true philosophy. He points to the antiquity of the doctrine. "It is lost," he says, "in the darkness of the middle ages. We have received this name from our forefathers, and it already appears distinctly in the sixteenth century. We possess several works of that time which put forward *contagium animatum* as a scientific doctrine, with the same confidence, with the same sort of proof, with which the 'Plastidulic soul' is now set forth."

These speculations of our "forefathers" will appeal differently to different minds. By some they will be dismissed with a sneer; to

[1] "We feel it an undeniable necessity," says Prof. Virchow, "not to sever the organic world from the whole, as if it were something disjoined from the whole." This grave statement cannot be weakened by the subsequent pleasantry regarding "Carbon & Co."

others they will appear as proofs of genius on the part of those who enunciated them. There are men, and by no means the minority, who, however wealthy in regard to facts, can never rise into the region of principles; and they are sometimes intolerant of those who can. They are formed to plod meritoriously on the lower levels of thought, unpossessed of the pinions necessary to reach the heights. They cannot realize the mental act—the act of inspiration it might well be called—by which a man of genius, after long pondering and proving, reaches a theoretic conception which unravels and illuminates the tangle of centuries of observation and experiment. There are minds, it may be said in passing, who at the present moment stand in this relation to Mr. Darwin. For my part, I should be inclined to ascribe to penetration rather than to presumption the notion of a *contagium animatum*. He who invented the term ought, I think, to be held in esteem; for he had before him the quantity of fact and the measure of analogy that would justify a man of genius in taking a step so bold. "Nevertheless," says Prof. Virchow, "no one was able throughout a long time to discover these living germs of disease. The sixteenth century did not find them, nor did the seventeenth, nor the eighteenth." But it may be urged, in reply to this, that the theoretic conjecture often legitimately comes first. It is the forecast of genius which anticipates the fact and constitutes a spur toward its discovery. If instead of being a spur the theoretic guess rendered men content with imperfect knowledge, it would be a thing to be deprecated. But in modern investigation this is distinctly not the case; Darwin's theory, for example, like the undulatory theory, has been a motive power and not an anodyne. "At last," says Prof. Virchow, "in the nineteenth century we have begun little by little really to find *contagia animata*. So much the more honor is due to those who, three centuries in advance, so put together the facts and analogies of contagious disease as to divine its root and character. Prof. Virchow seems to deprecate the "obstinacy" with which this notion of a *contagium vivum* emerged. Here I should not be inclined to follow him; because I do not know, nor does he tell me, how much the discovery of facts in the nineteenth century is indebted to the stimulus derived from the theoretic discussions of preceding centuries. The genesis of scientific ideas is a subject of profound interest and importance. He would be but a poor philosopher who would sever modern chemistry from the efforts of the alchemists, who would detach modern atomic doctrines from the speculations of Lucretius and his predecessors, or who would claim for our present knowledge of contagia an origin altogether independent of the efforts of our "forefathers" to penetrate this enigma.

Finally, I do not know that I should agree with Prof. Virchow as to what a theory is or ought to be. I call a theory a principle or conception of the mind which accounts for observed facts, and which helps us to look for and predict facts not yet observed. Every new discovery

which fits into a theory strengthens it. The theory is not a thing complete from the first, but a thing which grows, as it were asymptotically, toward certainty. Darwin's theory, as pointed out nine or ten years ago by Helmholtz and Hooker, was then exactly in this condition of growth; and had they to speak of the subject to-day they would be able to announce an enormous strengthening of the theoretic fibre. Fissures in continuity which then existed, and which left little hope of being ever spanned, have been since bridged over, so that the further the theory is tested the more fully does it harmonize with progressive experience and discovery. We shall probably never fill all the gaps; but this will not prevent a profound belief in the truth of the theory from taking root in the general mind. Much less will it justify a total denial of the theory. The man of science who assumes in such a case the position of a denier is sure to be stranded and isolated. The proper attitude, in my opinion, is to give as nearly as possible to the theory during the phases of its growth a proportionate assent; and, if it be a theory which influences practice, our wisdom is to follow its *probable* suggestions where more than probability is for the moment unattainable. I write thus with the theory of *contagium vivum* more especially in my mind, and must regret the attitude of denial assumed by Prof. Virchow toward that theory. "I must beg my friend Klebs to pardon me," he says, "if, notwithstanding the late advances made by the doctrine of infectious fungi, I still persist in my reserve so far as to admit only the fungus which is really proved, while I deny all other fungi so long as they are not actually brought before me." Prof. Virchow, that is to say, will continue to deny the germ theory, however great the probabilities on its side, however numerous the cases of which it renders a just account, until it has ceased to be a theory at all, and has become a congeries of sensible facts. Had he said, "As long as a single fungus of disease remains to be discovered, it is your bounden duty to search for it," I should cordially agree with him. But by his unreserved denial he quenches the light of probability which ought to guide the practice of the medical man. Both here and in relation to the theory of evolution excess on the one side has begotten excess on the other.

In publishing the volume of "Fragments," to which the foregoing article is introductory, I could not entirely ignore the criticisms which one or two among them have evoked. Of such strictures, however, my knowledge is incomplete, their authorship causing me to give some of them a spacious berth. Nor as regards those with which I am acquainted have I deemed it necessary to offer direct refutations. They fall spontaneously to pieces in presence of the facts here set forth.—*Author's advance sheets.*

ASTRONOMICAL MAGNITUDES AND DISTANCES.

By Professor H. S. CARHART.

THE magnitudes and distances considered in physical astronomy are so immense that we cannot hope to reach even a faint conception of them except by illustration and comparison. If even then, with our best effort, we fail to measure up to the magnificent dimensions of the universe, the attempt will at least enlarge our intellectual conceptions, and lead us out mentally into a broader place.

The results reached by modern astronomy, respecting the dimensions and distances of the heavenly bodies, are based on two lines, the radius (or semi-diameter) of the earth and the radius of its orbit; the former is accurately known, the latter approximately. In modern times the highest refinements of engineering skill have been applied to the measurement of base-lines, which furnish through triangulation arcs of a meridian. So thoroughly has this work been done that, in the opinion of Prof. Young, the error in the ascertained length of the earth's equatorial radius cannot exceed 200 feet. This radius forms our base-line for broader operations. The equatorial, horizontal parallax of the moon, or the angle subtended at the moon by the earth's equatorial radius, is found to have an average value of $57' 2''$. Hence by plane trigonometry the moon's mean distance is 238,885 miles, or nearly ten times the circumference of the earth. Light, with a velocity of 186,500 miles a second, travels from the earth to the moon and back again in two and a half seconds, thus producing that faint illumination of the dark portion of the new moon turned toward us. Knowing the moon's distance, the measurement of its apparent diameter in minutes of arc furnishes immediately its absolute diameter in miles.

So, then, this queen of the night, once supposed to be a kind of lantern, fed by exhalations from the ocean, is a body $\frac{1}{49}$ as large as the earth. It is our nearest celestial neighbor—in fact, a little outlying, condensed nebulosity; and if we had a weather-station on the lunar mountain Tycho, connected by telegraph with Washington, General Myer would receive the lunar weather-reports in fifteen seconds by electricity.

Aristarchus, in the third century before the Christian era, attempted to use the moon's distance to compute the greater distance of the sun; but the method failed, and astronomers were compelled to fall back on the radius of the earth as a base-line for a still grander triangulation. The parallax of Mars, at opposition, gave us the first approximation to the sun's distance; then the transit of Venus furnished a nearer estimate; latterly, Le Verrier, who found Neptune by figures, has also determined the distance of the sun by means of planetary perturbations; still a fourth method combines the retardation of the eclipses

of Jupiter's first satellite with the velocity of light, as determined by terrestrial measurement, and so measures off the millions of miles between us and the source of almost all our energy. These four methods, notably the last two, give us 92,360,000 miles as a near approximation to this long-sought distance. We have thus reduced this space by 3,000,000 miles, or about $\frac{1}{32}$ of the entire amount. Across this interval the radiant energy of the sun dashes in eight minutes thirteen seconds. Thermal electricity, which might be presumed to exist at the sun in great quantity, would traverse the distance in one hour thirty-six minutes. Sensation travels along our nerves at the slow rate of about 150 feet a second. Imagine an infant with an arm long enough to reach the sun. It would have to live 102 years to know that it had burned its hand in the solar fires. Counting three a second day and night, it would require an entire year to count the miles intervening between us and the sun; and to count the distance in feet, at the same rate, would consume 5,280 years, or nearly as much time as has elapsed since the introduction of man upon the earth, according to Biblical chronology.

The sun's distance being ascertained, its absolute diameter is determined from the apparent by the process applied to the moon. A near approximation to the sun's radius is 430,680 miles. Imagine the earth at the sun's centre: its surface would appear as far distant as does now the celestial vault, and the moon's orbit would fall nearly 200,000 miles within the surface, or little more than half-way from the centre out. A locomotive at thirty miles an hour would run from centre to surface in 1.63 years. Jules Verne got his traveler around the world in eighty days; at the same rate it would take him twenty-four years to make the circuit of the sun. Its volume is 1,334,000 times the earth's; but its mass, on account of its less density, is only 323,386 times as great. We say *only*, because the ratio of masses is so much less than that of volumes. But when we reflect that the spectroscope shows at least many terrestrial elements present in the sun, and that the sun contains enough of such substantial stuff as Mother Earth consists of to make more than 300,000 like her, we are prepared to admit that the ratio between the masses even is large enough for all practical purposes.

Vast and incomprehensible as we have found our distance from the sun to be, we have still to contemplate far greater reaches within the limits of the solar system. Jupiter holds on its silent course $5\frac{2}{10}$ as far away from the sun as the earth, and therefore receives only $\frac{1}{27}$ the intensity of solar radiant energy. Saturn is nearly twice as far distant as Jupiter; Uranus more than twice as far as Saturn; while Neptune glimmers at thirty times the earth's distance with light that has consumed eight and a quarter hours in flashing twice across this vast abyss since leaving the sun. At that distant boundary the light and heat of the sun have only $\frac{1}{900}$ the intensity that we enjoy, while its apparent diameter, observed from that position, would shrink to 64″,

or little more than the greatest apparent diameter of Venus. We modestly lay claim to this small corner of the universe, denominated the solar system, and assert our right to possession by calling it *ours*. What is the area of this plane bounded by Neptune's orbit, with which the planes of the other planetary orbits nearly coincide? What is the space swept by the radius-vector of this planetary child of Adams's and Le Verrier's calculations? Since circles are as the squares of their radii, this area is 900 times that comprised within the earth's orbit. Breaking this unit up into smaller ones, we find it contains twenty-six billions, five hundred millions of millions of square miles; or, with reference to the earth's entire surface, the ratio between it and the area of its orbit is 13,520,000. But Neptune's orbit exceeds this 900 times!

Conceive this orbit immersed in the universal ether, like an immense ring mapped out on the surface of still water. A pebble dropped at the centre of this ring would send its widening wavelets outward with a perfectly definite velocity. So a wave of light, emanating from the sun, with a length of no more than the $\frac{11}{1000}$ part of an inch, is propagated through this universal ether with such rapidity that in four hours and nine minutes it describes the entire area comprised within Neptune's path around the sun.

Across this vast interval quivers, too, in some mysterious way, that universal influence that we call gravitation. But at that outlying point, where Neptune holds on its silent course, it no longer exercises that dominant sway that characterizes it at the earth. The earth moves through 18.4 miles of its orbit every second, and is deflected from a straight line by the sun during that interval a little less than $\frac{13}{100}$ *of an inch* (0.11598 inch). Neptune travels 3.35 miles a second, and is deflected from a straight line during the same time only about $\frac{13}{100000}$ of an inch (0.000129 inch); yet by that slight pull the sun asserts its mastery, and brings Neptune round once in 164 years.

Vast as is this field of solar operations, we demand a still broader sphere for the exercise of our intellectual faculties. The successive eminences on which Astronomy has planted her appliances for more advanced operations stand related to each other as the terms, not of an arithmetical, but of a geometrical progression. Having settled the relative distances of this rather unsocial family of planets, the next advance is on to the stars. From the measurement of a base-line a few miles in extent, the astronomer essays, with undaunted hardihood, to fathom by triangulation the depths of space. The dog bays at the moon, the child stretches out its tiny hand to pluck the stars from the sky, and the astronomer applies his measuring-rod along the vibrating lines of light so far into immensity that blazing suns, exceeding in brightness the mid-day splendor of our own, dwindle to the luminous points of twinkling stars.

When Copernicus, the Polish astronomer, sought to extricate astronomy from the hopeless complexity into which it had become en-

tangled by cycles, epicycles, and eccentric positions, and proclaimed the heliocentric system, his opponents objected that the earth's axis, produced to the celestial sphere, with its successive positions day after day parallel to each other, should be seen to describe a circle in the heavens as the earth sweeps round through its orbit of nearly 600,000,000 miles in length. Copernicus replied that it does describe such a circle; but the stars, by reference to which it can alone be mapped out, are so distant that the circle of almost 100,000,000 miles' radius there dwindles to a point and vanishes by perspective. To reverse the line of sight, let us suppose ourselves transported to the pole-star and looking back upon the orbit of the earth. So vast is the distance that this elliptical orbit contracts almost to the infinitesimal dimensions of a point; for, at that distant station, the earth's orbital diameter subtends an angle of only 0.182″, or twice the angle called the parallax of the star. Such is the distance that the astronomer has successfully attempted to measure, starting with a primary triangle based on a determined line of only a few miles in length.

The nearest fixed star is *Alpha Centauri*, with a parallax of 0.928″, corresponding to a distance of 20,518,000 millions of miles. Light, traveling at the rate of 186,500 miles a second, requires 3.5 years to reach us from this nearest star. So the solar system, with its immense distances, is yet alone in the universe of stars; and our central luminary is separated so far from other suns that the distance to its outmost planet is almost a vanishing quantity in comparison with the distance to its nearest starry neighbors. We gaze upon the glittering heavens at night, and wrap in thought a canopy of shining stars about our earth as if it were an ornamented mantle; but could we take our station on a silent planet circling round some other starry sun, our sun would take its place as only one among the mazes of the stars.

How brilliantly Sirius shines with pure white light in the evening sky! Yet the earth has circled *seventeen times* round the sun since the light that the eye gathers to an image of the Dog-star left that glorious orb. Patiently the astronomer centres that little circle around which the pole-star sheds its guiding light, that he may adjust his instrument to parallelism with the axis of a revolving world. But since that light left its source at the pole-star, a child has grown through youth to manhood, and in his hair the gray of silver lines has begun to develop under the cares of six-and-thirty years. And these are only our nearest neighbors among the stars!

For every star visible to the naked eye under the most favorable circumstances the great Washington telescope shows from 5,000 to 8,000 more. According to the best authorities, the first six magnitudes contain 5,904 stars. Only half of these can be seen above the horizon at once; and the sixth magnitude comprises 4,424. These can be seen distinctly only on very favorable nights; so that for ordinary observation only 740 stars are visible at any moment above the horizon. There are

only twenty stars of the first magnitude, that is, of the first degree of brightness. It is demonstrable that Sirius is a hundred and sixty times as bright intrinsically as our sun. From a comparison of Sirius with the moon, and the moon with the sun, it is found that sunlight is 6,000 million times brighter than that of Sirius. But since Sirius is 1,000,000 times more distant than our sun, if brought as near us, the intensity of its light would be increased in the ratio of the square of 1,000,000 or 1,000,000 millions. This quantity, divided by 6,000 millions, would show Sirius to be at least a hundred and sixty times as bright intrinsically as our sun.

It is fair, however, to suppose that the chief cause of difference of brightness of stars is difference of distance. If so, we then have the means of approximating to the distance of even telescopic stars. Herschel estimated that stars of the first order emit, on an average, light one hundred times as intense as those of the sixth; hence the latter must be at ten times the distance, the intensity of light varying inversely as the square of the distance. Sirius is 98,000,000 of millions of miles from us; stars of the sixth magnitude are therefore about 1,000 millions of millions distant, and their light reaches us only after a flight of 169 or 170 years.

The space-penetrating power of a telescope depends upon the ratio between its aperture and the pupil of the eye. Herschel estimated that his four-foot reflector penetrated 194 times as far as the naked eye; and, as the faintest stars visible to the naked eye are ten times as distant as the brightest, it follows that the faintest stars visible in the field of Herschel's telescope are 1,940 times as distant as Sirius or *Alpha Lyræ*. In other words, Sirius would still be visible if removed to about 2,000 times its present distance. With Lord Rosse's six-foot reflector Sirius would still be visible at 3,000 times its present distance. If, therefore, this brightest star in the heavens should suddenly shoot away from us with the velocity of light, it would remain visible to the naked eye twice 170 years, since 170 years would be consumed in its flight and 170 more in the return of the light; and with Lord Rosse's telescope it could be traced 100,000 years longer (twice 3,000 times 170 years). This is the lowest estimate, too, for Sirius is many times brighter than the average star of the first magnitude. If intrinsically only four times as bright, it could still be seen by the telescope so infinitely far into space that light from it could reach us only after the lapse of 100,000 years.

But we need not pause even at these distant telescopic suns. Beyond the stars that merely dot with points of light the telescopic field of view, hovering on the outskirts of this inconceivable space swept by the far-fathoming line of telescopic vision, are discerned faintly-defined masses too distant to be resolved into stars, whose hazy light is gathered from congeries of suns, the individual blazing brightness of which is reduced in our view to the fleecy films of unresolvable nebulæ. Even

imagination tires in winging its way to these star-clusters, so far removed from us that each one may be called another universe of God. From them nothing comes to us but the faint, palpitating throb of an ethereal wave; no tidings cross that gulf save what flew throughout the universe when He who made these systems first said, "Let there be *light*." And, if thought falters and figures fail in the presence of these infinitudes of distance, no less do they when the dimensions of these nebulous fields are contemplated. The nearest star, viewed with a power of 6,000 diameters, shows no proper disk, and is still only a brilliant point. Its diameter, though perhaps greater than that of our own sun, is still at least 6,000 times too small to come within the limits of unaided vision. But many nebulæ, though almost infinitely farther removed, are still of extent sufficient to more than fill the telescopic field. Who, then, can estimate their absolute dimensions?

Such, then, are the magnitudes and distances which the godlike human intellect has undertaken to determine. And still art vies with science to fashion lenses that shall gather at their focus still more and more of that luminous intelligence that discloses to the mind of man the secrets of the outside universe. But as the space-penetrating power of the telescope is increased, and the bright spots of light are resolved into groups of brilliant stars, more nebulous haze comes up from the deep distance, indicating that the visual ray is not yet long enough to fathom the mighty depths. There is still haze behind, independent of those nebulæ shown to be gaseous by the spectroscope. The telescopic ray has not yet shot entirely through the mighty distance, leaving only the deep, dark heavens beyond as the background of the brilliant picture. The words uttered by David spring to our lips with fuller meaning when we look out upon the glorious heavens illumined by the concentrated light of these latter days: "When I consider thy heavens, the work of thy fingers, the moon and the stars which thou hast ordained; what is man, that thou art mindful of him? or the son of man, that thou visitest him?"

HERBERT SPENCER BEFORE THE ENGLISH COPYRIGHT COMMISSION.[1]

QUESTION (*Chairman*). I need hardly ask, you are a writer of philosophical and scientific books?

Answer. I am.

Q. Would you give the commission your experience of the terms on which you published your first book?

[1] Tuesday, March 6, 1877: Lord John Manners, M. P., in the chair. Members of the commission present, Sir Henry T. Holland, Sir Louis Mallet, Sir Julius Benedict, Farrer Herschell, Dr. William Smith, J. A. Froude, Esq., Anthony Trollope, Esq., F. R. Daldy, Esq.

A. I published my first work, "Social Statics," at the end of 1850. Being a philosophical book, it was not possible to obtain a publisher who would undertake any responsibility, and I published it at my own cost. A publisher looks askance at philosophy, and especially the philosophy of a new man; hence I published on commission.

Q. Would you like to state what the result was?

A. The edition was 750; it took fourteen years to sell.

Q. Then with respect to your next work?

A. In 1855 I published the "Principles of Psychology;" I again tried in vain to get a publisher, and published again at my own cost. There were 750 copies, and the sale was very slow. I gave away a considerable number; the remainder, I suppose about 650, sold in twelve and a half years.

Q. Have you had any other similar cases?

A. Yes; I afterward, in 1857, published a series of Essays, and, warned by past results, I printed only 500. That took ten and a half years to sell. After that a second series of Essays and a little work on Education, which both had kindred results, but were not quite so long in selling. I should add that all these sales would have taken still longer but for the effect produced upon them by books published at a later period, which helped the earlier ones to sell.

Q. Have all these subsequent works to which you now refer been published in the same way?

A. No. Toward 1860 I began to be anxious to publish a "System of Philosophy," which I had been elaborating for a good many years. I found myself in the position of losing by all my books; and, after considering various plans, I decided upon the plan of issuing to subscribers in quarterly parts, and to the public in volumes when completed. Before the initial volume, "First Principles," was finished, I found myself still losing. During the issue of the second volume, the "Principles of Biology," I was still losing. In the middle of the third volume I was still losing so much, that I found I was frittering away all I possessed. I went back upon my accounts, and found that in the course of fifteen years I had lost nearly £1,200—adding interest, more than £1,200; and as I was evidently going on ruining myself, I issued to the subscribers a notice of cessation.

Q. Was that loss the difference between the money that you had actually spent in publishing the books and the money you had received in return?

A. Not exactly. The difference was between my total expenditure in publishing the books and living in the most economical way possible, and the total returns. That is to say, cutting down my expenses to the smallest amount, I lost £1,200 by the inadequate returns, and trenched to that extent upon capital.

Q. But you continued afterward, did you not, to publish?

A. I continued afterward, simply, I may say, by accident. On two

previous occasions, in the course of those fifteen years, I had been enabled to persevere, spite of losses, by bequests. On this third occasion, after the issue of the notice, property which I inherit came to me in time to prevent the cessation.

Q. May I ask how long it took before you began to be repaid for your losses?

A. My losses did not continue very long after that: the tide turned, and my books began to pay. I have calculated what length of time it has taken to repay my losses, and find they were repaid in 1874; that is to say, in twenty-four years after I began I retrieved my position.

Q. Then the commission understand that your books are now remunerative?

A. They are now remunerative, and for this reason: As I have explained, I had to publish on commission. Commission is a system which, throwing all the cost upon the author, is very disastrous for him if his books do not pay, and, as you see in this case, has been very disastrous to me; but when they do pay it is extremely advantageous, inasmuch as in that case the publisher who does the business takes only ten per cent., and the whole of the difference between cost and proceeds, minus that ten per cent., comes to the author. I have calculated what are my actual returns, on two suppositions. I have ascertained the percentage I get upon 1,000 copies, supposing that I set up the type solely for that 1,000 copies—supposing, that is, that the cost of composition comes into the cost. In that case I reap 30¾ per cent. But I reap much more. I was sanguine enough, when I began this series of books, to stereotype. The result is, that now I simply have to print additional thousands as they are demanded. If I suppose the cost of composition and stereotyping to have been paid for in the first edition, and only estimate the cost of paper and printing in the successive editions, then I am reaping 41¾ per cent. The actual percentage, of course, is one which lies between those two; but year by year, with each additional thousand, I approach more nearly to the limit of 41¾ per cent. I should point out that the result of this is that I receive, as may be supposed, a considerable return upon the moderate numbers sold.

Q. And that being so, can you tell the commission what in your opinion would have happened had there been in existence a system under which three years, say, after date of publication any one could have reprinted your books, paying you a royalty of ten per cent.?

A. The result would have been that my losses would not have been repaid now. After twenty-six years' work I should still have been out of pocket; and should be out of pocket for many years to come.

Q. (*Mr. Trollope*). Under such a system do you think that you would ever have recovered that money?

A. I am taking it on the most favorable supposition, merely supposing that all other things but percentage had remained the same.

Q. (*Chairman*). Assuming the system of royalty to be in existence,

what would be the result on your present returns, supposing losses to have been repaid?

A. Between two-thirds and three-fourths of those returns would be cut off. They would be reduced to little more than a fourth of their present amount.

Q. (*Sir H. Holland*). How do you arrive at that result?

A. By comparing the supposed percentage with the percentage I actually received.

Q. Assuming a royalty of ten per cent. upon the retail price?

A. Yes.

Q. (*Chairman*). Would it not be probable that the reduction in price of your books would so increase the sales that you would reap a larger return than you have supposed in the estimate that you have now given?

A. I think not, or very little. First of all, for the reason that the amount of reduction would not be anything like so great as at first sight appears. If a publisher issued rival editions of my books without my assent, on paying a royalty, he would only do so to make a profit beyond that which mere commission would bring. My present publisher is content with ten per cent. commission. A publisher who competed as a speculation would want to make his profit beyond the ten per cent. commission; as I ascertain, probably, at least a further ten per cent. Then there would be my own ten per cent. royalty. So that I find the reduction in price under such a royalty system would only be about fifteen per cent. That is to say, the reduction would be from 20*s.* to 17*s.* Now I am of opinion that a reduction of the price of one of my books by that amount would have but a small effect upon the sales, the market being so limited. Let me use an illustration: Take such a commodity as cod-liver oil, which is a very necessary thing for a certain limited class. Suppose it is contended that, out of regard for those to whom it is so necessary, retailers should be compelled to take a smaller profit, and you reduce the price by fifteen per cent. The consumption would be very little influenced, because there would be none except those who had it prescribed for them who would be willing to take it, and they must have it. Now take one of my books, say the "Principles of Psychology." Instead of calling it "*caviare* to the general," let us call it cod-liver oil to the general; I think it probable that if you were to ask ninety-nine people out of a hundred whether they would daily take a spoonful of cod-liver oil or read a chapter of that book, they would prefer the cod-liver oil. And if so it is quite clear, I think, that no lowering of the price by 3*s.* out of 20*s.* would in any considerable degree increase the number of persons who bought the "Principles of Psychology." The class is so limited and so special that there would be no increase of profit of a considerable kind in consequence of an increased number sold.

Q. (*Mr. Trollope*). But are there not many people who would have

benefited by cod-liver oil who cannot get it at present because of the price?

A. I think in all those cases in which they would be benefited they get it by hook or by crook when it is prescribed for them.

Q. And in the same way with your books, you think?

A. Yes. For instance, university men have to read them, and they would buy them in any case.

Q. (*Chairman*). What would have happened to you originally had there been a law giving a copyright only of short duration, under such an arrangement of percentage as that which you have just named?

A. I think it is tolerably obvious, from what I have already said, that I should not have been wholly deterred. I should have gone on losing for many years; but I think it is also clear that I should have stopped short much sooner than I did. Every author is naturally sanguine about his books; he has hopes which nobody else entertains. The result is that he will persevere, in the hope of at some time or other reaping some return, when to other persons there seems to be no probability of the kind. But supposing it becomes manifest to him that the copyright law is such that when his books succeed, if they ever do succeed, he will not get large profits, then the discouragement will be much greater, and he will stop much sooner. If I, for instance, instead of seeing that under the system of commission I should eventually, if I succeeded, repay myself and get a good return, had seen that eventually, if I succeeded, I should receive but small gains, I should have given it up.

Q. Are there other publications which you have undertaken besides those to which you have already referred?

A. Yes. About ten years ago I commenced preparing works now published under the name of "Descriptive Sociology," in large folio parts, and containing tables and classified extracts representing the civilizations of various societies. I employed gentlemen to make these compilations.

Q. Do you wish to state what has been the result of that undertaking so far?

A. Yes. I made up my accounts last Christmas. I had then in the course of those ten years expended £2,958 odd upon eight parts (five published and three in hand), and my net return from sales of the five parts published in England and America was £608 10*s.*

Q. May I ask whether you ever expect to get back the money that you have expended?

A. I may possibly get back the printing expenses on the earliest part, and most popular part, that dealing with the English civilization, in 1880, at the present rate of sale. The printing expenses of the other parts I do not expect to get back for many years longer. The cost of compilation I expect to get back if I live to be over a hundred.

Q. (*Mr. Daldy*). You spoke of the circulation in England and America. May I ask, do you send stereotype-plates to America?

A. I did at first send stereotype-plates to America, but, the thing having proved to be so great a loss, I now send a portion of the printed edition.

Q. (*Chairman*). May I ask why do you expect repayment of the cost of compilation to be so slow as you stated in your answer to my last question?

A. The reason is, that I made a promise to the compilers entailing that. The compilers are university men, to whom I could afford to give only such salaries as sufficed for their necessary expenses. To make the thing better for them, and to be some incentive, I told them that, when the printing expenses on any one part were repaid, I would commence to divide with the compiler of it the returns on subsequent sales; the result being that the cost of compilation comes back to me only at half the previous rate. I name this because it shows that, in the absence of a long copyright, I could have given no such contingent advantage to the compilers. I wish to point out another way in which a short copyright would have impeded me. As a further incentive to these compilers to do their work well, as also to make the prospect better for them, I gave them to understand that the copyrights and the stereotype-plates would be theirs after my death. Of course, with a short copyright I could not have done that.

Q. Then in your opinion it is only by a long duration of copyright that you can be enabled to recover any considerable part of the money that you have sunk in these publications?

A. Certainly. If it were possible for any one to reprint, such small return as goes toward diminishing this immense loss would be in part intercepted.

Q. But if this work, which you call "Descriptive Sociology," is so unremunerative, how do you imagine you would be in danger of having it reprinted under the suggested system of royalty?

A. It appears at first sight not a rational expectation, but it is perfectly possible. Each number of the work consists of a set of tables and a set of classified extracts. It was suggested by a reviewer of the first part, the English part, that the tables should be separately printed, mounted on boards, and hung up in schools. The suggestion was a good one, and I have even had thoughts of doing it myself. A publisher might take up that suggestion, and might issue those independently of me, and diminish what small sale I now have. Again, the work is very cumbrous and awkward; that can hardly be helped; but a publisher might see that the extracts arranged in ordinary volume form would be valuable by themselves apart from the tables, and might get a good sale independently; and again my small returns would be cut into.

Q. (*Sir H. Holland*). That objection of yours would be partly met

by the suggestion of Mr. Macfie, who brought this question of royalty before us, because his suggestion is, that no reprint is to differ from the original edition without the author's consent, either in the way of abbreviation, enlargement, or alteration of the text. Therefore, under that regulation, if that is carried out, a publisher could not print half of this book without your consent?

A. That would so far, if it can be practically worked out, meet my objection.

Q. (*Mr. Trollope*). But you have stated that you thought yourself of using this form of abridgment to which allusion is made?

A. I have.

Q. And if this form of abridgment when made by you could be republished again by anybody else, then your profit would be interfered with?

A. No doubt of it.

Q. (*Chairman*). Supposing the suggested system of short copyright and royalty had been in force, would you have undertaken these works to which you have referred?

A. Certainly not. The enterprise was an unpromising one, pecuniarily considered, and it would have been almost an insane one, I think, had there not been the possibility of eventually getting back some returns from sales that were necessarily very slow. Moreover, the hopes under which the compilers have worked I could never have given to them.

Q. Then are we to gather from your evidence that the system of short copyright and royalty would be injurious to the books of the graver class which do not appeal to the popular tastes?

A. I think so; it would be especially injurious to that particular class which of all others needs encouragement.

Q. (*Sir H. Holland*). As requiring most thought and brain-work on the part of the author?

A. Yes, and being least remunerative.

Q. (*Chairman*). I understand you to say that in all these cases you have not parted with the copyright yourself?

A. No, I have not.

Q. Now, assuming that the authors of these graver books sold their copyrights, do you think that this royalty system would still act prejudicially upon them?

A. I think very decidedly. I have understood that it is contended that authors who sell their copyrights would not be affected by this arrangement. One of the answers I heard given here to-day sufficed to show that that is not true; inasmuch as a publisher who had to meet these risks would not give as much for copyright as he would otherwise give. His argument would be unanswerable. He would say: "Your book is a success, or not a success; if not a success, I lose what I give you for copyright; if a success, I shall have it reprinted upon

me, and again I shall lose what I give you for copyright. I must, therefore, reduce the amount which I give for the copyright." Moreover, I believe that the reduction in the value of copyrights would be much greater than the facts justified. In the first place, the publisher himself would look to the possibility of reprinting with a fear beyond that which actual experience warranted. Frequently a suggested small danger acts upon the mind in a degree out of all proportion to its amount. Take such a case as the present small-pox epidemic, in which you find one person in 30,000 dies in a week; in which, therefore, the risk of death is extremely small. Look at this actual risk of death and compare it with the alarms that you find prevailing among people. It is clear that the fear of an imagined consequence of that kind is often much in excess of the actual danger. Similarly, I conceive that the publisher himself would unconsciously over-estimate the danger of reprints. But beyond that he would exaggerate his over-estimate as an excuse for beating down copyright. He would say to the author: "You see this danger; I cannot face so great a risk without guarding myself; and you must submit to a large reduction."

(Mr. Spencer was subsequently called before the committee again, and we shall give his interesting evidence next month.)

THE BEGINNING OF NERVES IN THE ANIMAL KINGDOM.

By GEORGE J. ROMANES.

NERVE-TISSUE universally consists of two elementary structures, viz., very minute nerve-cells and very minute nerve-fibres. The fibres proceed to and from the cells, so in some cases serving to unite the cells with one another, and in other cases with distant parts of the animal body. Nerve-cells are usually found collected together in aggregates, which are called nerve-centres or ganglia, to and from which large bundles of nerve-fibres come and go.

To explain the *function* of nerve-tissue, it is necessary to begin by explaining what physiologists mean by the term "excitability." Suppose that a muscle has been cut from the body of a freshly-killed animal; so long as it is not interfered with in any way, so long will it remain quite passive. But every time a stimulus is supplied to it, either by means of a pinch, a burn, an electrical shock, or a chemical irritant, the muscle will give a single contraction in response to every stimulation. And it is this readiness of organic tissues to respond to a suitable stimulus that physiologists designate by the term "excitability."

Nerves, no less than muscles, present the property of being excitable. If, together with the excised muscle, there had been removed from the animal's body an attached nerve, every time any part of this nerve is stimulated the attached muscle will contract as before. But it must be carefully observed that there is this great difference between these two cases of response on the part of the muscle—that, while in the former case the muscle responded to a stimulus *applied directly to its own substance*, in the latter case the muscle responded to a stimulus applied *at a distance from its own substance*, which stimulus was then *conducted* to the muscle by the nerve. And in this we perceive the characteristic function of nerve-*fibres*, viz., that of conducting stimuli to a distance. The function of nerve-*cells* is different, viz., that of accumulating nervous energy; and, at fitting times, of discharging this energy into the attached nerve-fibres. The nervous energy, when thus discharged, acts as a stimulus to the nerve-fibre; so that, if a muscle is attached to the end of a fibre, it contracts on receiving this stimulus. I may add that, when nerve-cells are collected into ganglia, they often appear to discharge their energy spontaneously; so that in all but the very lowest animals, whenever we see apparently *spontaneous* action, we infer that ganglia are probably present. Lastly, another important distinction must be borne in mind—the distinction, namely, which I now draw between muscle and nerve. A stimulus applied to a nerveless muscle can only course through the muscle by giving rise to a visible wave of contraction, which spreads in all directions from the seat of disturbance as from a centre. A nerve, on the other hand, conducts the stimulus without undergoing any change of shape. Now, in order not to forget this distinction, I shall always speak of muscle-fibres as conveying a *visible* wave of *contraction*, and of nerve-fibres as conveying an *invisible*, or *molecular*, wave of *stimulation*. Nerve-fibres, then, are functionally distinguished from muscle-fibres—and also from protoplasm—by displaying the property of conducting invisible, or molecular, waves of stimulation from one part of an organism to another, so establishing physiological continuity between such parts, *without the necessary passage of contractile waves*.

Such being the structure and the function of nerve-tissue in its fully evolved form, I will now proceed to give the results of my researches on the structure and function of nerve-tissue where this tissue is first found to occur in the ascending series of animal life. The animals in which it so occurs are the *Medusæ* or jelly-fishes, which must be familiar to all who frequent the seaside. These animals present the general form of a mushroom. The organ which occupies the same position as the stalk does in the mushroom is the mouth and stomach of the medusa, and is called the polypite; while the organ which resembles in shape the dome of the mushroom consitutes the main bulk of the animal, and is called the swimming-bell. Both the polypite and the swimming-bell are almost entirely composed of a thick, transparent, and non-

contractile jelly; but the whole surface of the polypite, and the whole *concave* surface of the bell, are overlaid by a thin layer, or sheet, of contractile tissue. This tissue constitutes the earliest appearance in the animal kingdom of true muscular fibres. The thickness of this continuous layer of incipient muscle is pretty uniform, and is nowhere greater than that of very thin paper. The margin of the bell supports a series of highly contractile tentacles, and also another series of bodies which are of great importance in the following researches. These are the so-called marginal bodies, which are here represented, but the structure of which I need not describe. Lastly, it may not be superfluous to add that all the *Medusæ* are locomotive. The mechanism of their locomotion is very simple, consisting merely of an alternate contraction and relaxation of the entire muscular sheet which lines the cavity of the bell. At each contraction of this muscular sheet the gelatinous walls of the bell are drawn together; the capacity of the bell being thus diminished, water is ejected from the open mouth of the bell backward, and the consequent reaction propels the animal forward. In these swimming movements systole and diastole follow one another with as perfect a rhythm as they do in the beating of a heart.

FIG. 1.

Previous to my researches, the question as to whether or not the *Medusæ* possess a nervous system was one of the most vexed questions in biology—some eminent naturalists maintaining that they could detect microscopical indications of nervous tissues, and others maintaining that these indications were delusive—the deliquescent nature of the gelatinous tissues rendering microscopical observation in their case a matter of great difficulty. But amid all this controversy no one appears to have thought of testing the question by means of physiological experiments as distinguished from microscopical observations. Accordingly, I made the experiment of cutting off now one part and now another part of a jelly-fish, in order to see whether by so doing I could alter the character of its movements in such a way as to show that I had removed nerve-centres or ganglia. The results which I obtained were in the highest degree astonishing. For, on removing the extreme margin of the swimming-bell, I invariably found that the operation caused immediate, total, and permanent paralysis of the entire organ. That is to say, if, with a pair of scissors, I cut off the whole marginal rim of the bell, carrying the cut round just above the insertion of the tentacles, the moment the last atom of the margin was removed, the

pulsations of the bell instantly and forever ceased. On the other hand, the severed margin continued its pulsations with vigor and pertinacity, notwithstanding its severance from the main organism. For hours and even for days after its removal the severed margin would continue its rhythmical contractions; so that the contrast between the death-like quiescence of the mutilated bell and the active movements of the thread-like portion which had just been removed from its margin was a contrast as striking as it is possible to conceive.

I may here add that, although excision of the margin of the bell thus completely destroys the *spontaneity* of the bell, it does not at all diminish the *excitability* of the bell; so that, although the mushroom-shaped mass will never move of its own accord after having been thus mutilated, it will give any number of locomotor contractions in response to an equal number of artificial stimulations, just in the same way as a frog with its head (nerve-centres of spontaneity) removed will give any number of hops in response to successive stimulations.

These experiments, therefore, prove conclusively that, in the extreme marginal rim of all the numerous species of *Medusæ* which I examined, there is situated an intensely localized system of nervous centres, to the functional activity of which the rhythmical contractions of the swimming-bell are exclusively due. And as the *Medusæ* are thus the lowest animals in which a nervous system has yet been or probably ever will be discovered, we have in them the animals upon which we may experiment with the best hope of being able to elucidate all questions concerning the origin and endowments of primitive nervous tissues. I may here add that these experiments were independently made by Dr. Eimer, of Würzburg.

After I had made the observation which I have described, it seemed to me desirable to follow it up with a number of other physiological, as distinguished from histological, researches. For I was much struck by the certainty and precision of the results which I had obtained by experiment, as distinguished from the uncertainty and disagreement of the results which had previously been obtained by the histological methods. Accordingly, I decided, in the first instance, to feel my way in the direction of physiological experiment before beginning that systematic histological research which, sooner or later, it was manifestly imperative to make. Study of function having so far guided the study of structure as to show that it was in the margin of the *Medusæ* that we must look for the principal if not the exclusive supply of central nervous tissue, it seemed desirable to ascertain how much light a further study of function might throw on the character and the distribution of the peripheral nervous tissue.[1] Accordingly, I began my physiological work chiefly with the view of guiding my subsequent histo-

[1] Although it sounds somewhat paradoxical to speak of the central nervous tissue as distributed on the periphery of a circular animal, and of the peripheral nervous tissue as occupying all the more centrally situated parts, the paradox is unavoidable.

logical work. But, as the physiology of the subject continued to open up in the wonderful way in which it did, I felt it was undesirable either, on the one hand, to suspend this part of the inquiry, or, on the other hand, any longer to defer a thorough investigation of the histological part. I therefore represented the case to my friend Mr. Schäfer, who very kindly consented to join me in Scotland, with the view of coöperating with me in the research. The histological results which he has obtained from a most skillful and painstaking investigation are in the highest degree interesting. He worked chiefly with *Aurelia aurita*, and found that the tissue which performs the ganglionic function in the marginal bodies is of the nature of modified epithelium-cells, the ganglionic function of which could scarcely have been suspected but for the paralyzing effects which are produced by their excision. From these marginal ganglia there radiate what he regards as delicate pale nerve-fibres, which sometimes present the appearance of fibrillation. These fibres spread over the entire expanse of the muscular sheet in great numbers. It will thus be seen that these microscopical researches of Mr. Schäfer fully bear out my inference from the result of physiological experiments, which was previously published at the Royal Society—the inference, namely, that the entire muscular sheet of the *Medusæ* is overspread by a dense plexus of nervous channels. But these researches of Mr. Schäfer tend to negative another inference which was published at the Royal Institution—the inference, namely, as to the degree in which these channels are *differentiated*.[1] As the facts on which this inference was based have not been previously published in the *Fortnightly Review*, and as, apart from the dubious inference, they are facts of the first importance, it is necessary that I should here very briefly restate them. The annexed woodcut (Fig. 2) represents a specimen of *Aurelia aurita* with its polypite cut off at the base, and the under or concave surface of the bell exposed to view. The bell, when fully expanded, as here represented, is about the size of a soup-plate, and in it all

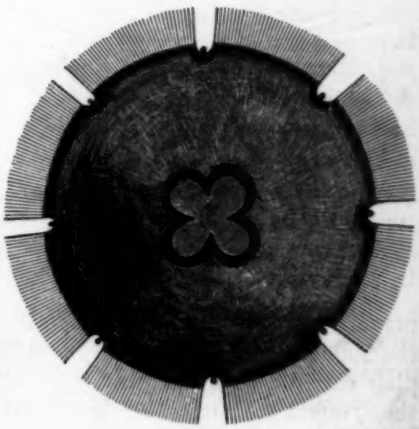


Fig. 2.

[1] I may here state that, previous to Mr. Schäfer's researches, I had observed both the tissue-elements which he describes; but I hesitated to pronounce upon their nervous character. It will thus be understood that even now, without wishing to dispute the accuracy of his judgment in this matter, I do wish it to be known that the responsibility of this judgment rests entirely with my friend.

the ganglia are collected into these eight marginal bodies, as proved by the fact that on cutting out all the eight marginal bodies paralysis of the bell ensues. Therefore, if the reader will imagine this diagram to be overspread with a disk of muslin, the fibres of which start from one or other of these marginal ganglia, he will gain a tolerably correct idea of the lowest nervous system in the animal kingdom. Now suppose that seven of these eight ganglia are cut out, the remaining one then continues to supply its rhythmical discharges to the muscular sheet of the bell, the result being, at each discharge, two contractile waves, which start at the same instant, one on each side of the ganglion, and which then course with equal rapidity in opposite directions, and so meet at the point of the disk which is opposite to the ganglion. Suppose now a number of radial cuts are made in the disk, according to such a plan as this, wherein every radial cut deeply overlaps those on either side of it. The contractile waves which now originate from the ganglion must either become blocked and cease to pass round the disk, or they must zigzag round and round the tops of these overlapping cuts. Now, remembering that the passage of these contractile waves is presumably dependent on the nervous network progressively distributing the ganglionic impulse to the muscular fibres, surely we should expect that two or three overlapping cuts, by completely severing all the nerve-fibres lying between them, ought to destroy the functional continuity of these fibres, and so to block the passage of the contractile wave. Yet this is not the case; for, even in a specimen of *Aurelia* so severely cut as the one here represented, the contractile waves, starting from the ganglion, continued to zigzag round and round the entire series of sections.

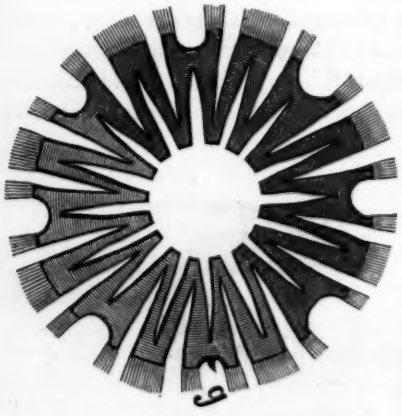


FIG. 3.

The same result attends other forms of section. Here, for instance, seven of the marginal ganglia having been removed as before, the eighth one was made the point of origin of a circumferential section, which was then carried round and round the bell in the form of a continuous spiral—the result, of course, being this long ribbon-shaped strip of tissue with the ganglion at one end, and the remainder of the swimming-bell at the other. Well, as before, the contractile waves always originated at the ganglion; but now they had to course all the way along the strip until they arrived at its other extremity; and, as each wave arrived at that extremity, it delivered its influence into the remainder of the swimming-bell, which thereupon contracted.

Now, in this experiment, when the spiral strip is only made about half an inch broad, it may be made more than a yard long before all the bell is used up in making the strip; and as nothing can well be imagined as more destructive of the continuity of a nerve-plexus than this spiral mode of section must be, we cannot but regard it as a very remarkable fact that the nerve-plexus should still continue to discharge its functions. Indeed, so remarkable does this fact appear, that to avoid accepting it

FIG. 4.

we may well feel inclined to resort to another hypothesis—namely, that these contractile waves do not depend for their passage on the nervous network at all, but that they are of the nature of muscle-waves, or of the waves which we see in indifferentiated protoplasm, where all parts of the mass being equally excitable and equally contractile, however severely we cut the mass, so long as we do not actually divide it, contractile waves will pass throughout the whole mass. But this very reasonable hypothesis of the contractile waves in the *Medusæ* being possibly nothing other than muscle-waves, is negatived by another fact of a most extraordinary nature. At the beginning of this article I stated that the distinguishing function of nerve consists in its power of conducting stimuli to a distance, irrespective of the passage of a contractile wave; and I may here add that, when a stimulus so conducted reaches a ganglion or nerve-centre, it causes the ganglion to discharge by so-called "reflex action." Now, this distinguishing function of nerve can plainly be proved to be present in the *Medusæ*. For instance, take such a section of *Aurelia* as this one (Fig. 5), wherein the bell has been cut into the form of a continuous parallelogram of tissue with the polypite and

a single remaining ganglion at one end. (The cuts interposed in the parallelogram may for the present be neglected.) Now, if the end-mark *a* of the nervo-muscular sheet most remote from the ganglion be gently brushed with a camel's-hair brush—i. e., too gently to start a responsive contractile wave—the ganglion at the other end will shortly afterward discharge, as shown by its starting a contractile wave at its own end of the parallelogram *b*, thus proving that the stimulus caused

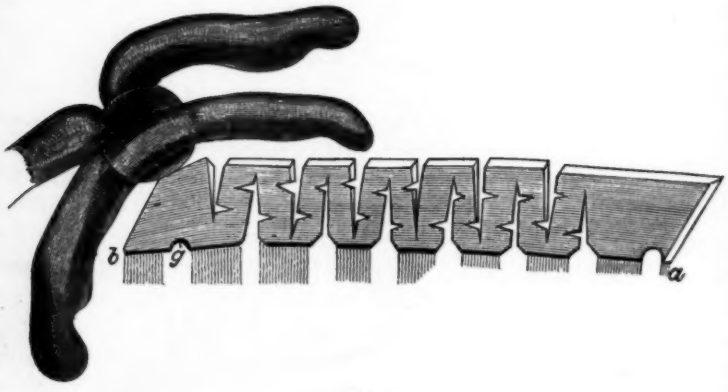


FIG. 5.

by brushing the tissue at the other end, *a*, must have been conducted all the way along the parallelogram to the terminal ganglion *b*, so causing the terminal ganglion to discharge by reflex action. Indeed, in many cases, the passage of this nervous wave of stimulation admits of being actually *seen*. For the numberless tentacles which fringe the margin of *Aurelia* are more highly excitable than is the general contractile tissue of the bell; so that, on brushing the end *a* of the parallelogram remote from the ganglion, the tentacles at this end respond to the stimulus by a contraction, then those next in the series do the same, and so on—a wave of contraction being thus set up in the tentacular fringe, the passage of which is determined by the passage of the nervous wave of stimulation in the superjacent nervous network. This tentacular wave is here represented as having traversed half the whole distance to the terminal ganglion, and when it reaches that ganglion it will cause it to discharge by reflex action, so giving rise to a visible wave of muscular contraction passing in the direction *b a*, opposite to that which the nervous or tentacular wave had previously pursued. Now, this tentacular wave, being an optical expression of the passage of a wave of stimulation, is a sight as beautiful as it is unique; and it affords a first-rate opportunity of settling this all-important question, namely—will this conductile or nervous function prove itself as tolerant toward a section of the tissue as the contractile or muscular function has already proved itself to be? For, if so, we shall

gain nothing on the side of simplicity by assuming that the contractile waves are merely muscle-waves, so long as the *undoubtedly nervous* waves are equally able to pass round sections interposed in their path. Briefly, then, I find that the nervous waves of stimulation are quite as able to pass round these interposed sections as are the waves of contraction. Thus, for instance, in this specimen (Fig. 5), the tentacular wave of stimulation continued to pass as before, even after I had submitted the parallelogram of tissue to the tremendously severe form of section which is represented in the diagram. And this fact, I am not afraid to say, is one of the most important that has ever been brought to light in the whole range of invertebrate physiology. For what does it prove? It proves that the distinguishing function of nerve, where it first appears upon the scene of life, admits of being performed vicariously to almost any extent by all parts of the same tissue-mass. If we revert to our old illustration of the muslin as representing the nerve-plexus, it is clear that, however much we choose to cut the sheet of muslin with such radial or spiral sections as are represented in the diagram, one could always trace the threads of the muslin with a needle round and round the disk, without once interrupting the continuity of the tracing; for, on coming to the end of a divided thread, one could always double back on it and choose another thread which might be running in the required direction. And this is what we are now compelled to believe takes place in the fibres of this nervous network, if we assume that these visible fibres are the only conductive elements which are present. Whenever a stimulus-wave reaches a cut, we must conclude that it doubles back and passes into the neighboring fibres, and so on, time after time, till it succeeds in passing round and round any number of overlapping cuts.

Now, it was in view of this almost unlimited power of vicarious action on the part of the fibres composing the (then) hypothetical nervous plexus, that I was in the first instance inclined to suppose these nerve-fibres to be of a non-fully differentiated character; and although the above detailed experiments, and others of a similar kind, proved that an intimate network of such channels was present, I scarcely expected that they would admit of being distinguished by the microscope. But, not to give an inference the value of a fact, I was careful to state in the publication where this inference was adduced—viz., in the printed abstract of a Royal Institution lecture—that this position was only "provisional," and that, until I should have had "time to conduct a systematic inquiry concerning the histology of the *Medusæ*," the inference in question must be regarded as premature and uncertain."[1] Such a systematic inquiry has now shown that this provisional inference was

[1] I guarded the inference in this way, lest the fibres in question should afterward prove to be nerves; and it will therefore be observed that, supposing them to be nerves, the above inference cannot be negatived until it is shown that there are no other nervous channels present of a less differentiated character.

perhaps erroneous, and that, in any case, when stained with gold, some of the nervous channels show themselves in the form of fully differentiated nerves. Now this fact, it is needless to say, greatly enhances the interest of the previous experiments. If, as I formerly said, the proof of vicarious action being possible to an almost unlimited extent in these incipient nerve-fibres appeared to me one of the most interesting among the additions to our knowledge of invertebrate physiology, much more interesting does this proof become if we further learn that these incipient nerve-fibres are only incipient in the sense of constituting the earliest appearance of nerve-fibres in the animal kingdom. For if these *true* nerve-fibres admit, from the peculiarly favorable plan of their anatomical distribution, of being proved to be not improbably capable of vicarious action to so extraordinary a degree, we may become the more prepared to believe that nerve-fibres elsewhere are similarly capable of vicarious action. But the interest does not end here, for Mr. Schäfer's numerous preparations all show the highly remarkable fact that the nerve-fibres which so thickly overspread the muscular sheet of *Aurelia* do not constitute a true plexus, but that each fibre is comparatively short, and nowhere joins with any of the other fibres. That is to say, although the constituent fibres of the network cross and recross one another in all directions—sometimes, indeed, twisting around one another like the strands of a rope—they can never be actually seen to join, but remain anatomically isolated throughout their length. So that the simile by which I have represented this nervous network—the simile, namely, of a sheet of muslin overspreading the whole of the muscular sheet—is as a simile even more accurate than has hitherto appeared; for just as in a piece of muslin the constituent threads, although frequently meeting one another, never actually coalesce, so, in the nervous network of *Aurelia*, the constituent fibres, although frequently in contact, never actually unite.

Now, if it is a remarkable fact that in a fully differentiated nervous network the constituent fibres are not improbably capable of vicarious action to almost any extent, much more remarkable does this fact become when we find that no two of these constituent nerve-fibres are histologically continuous with one another. Indeed, it seems to me that we have here a fact as startling as it is novel. There can scarcely be any doubt that *some* influence is communicated from a stimulated fibre *a* to the adjacent fibre *b* at the point where these fibres come into close apposition. But what the nature of the process may be whereby a disturbance in the excitable protoplasm of *a* sets up a sympathetic disturbance in the anatomically separate protoplasm of *b*, supposing it to be really such—this is a question concerning which it would as yet be premature to speculate.[1] But if, for the sake of a name, we call this

[1] That it can scarcely be an *electrically inductive* effect would seem to be shown by the fact that such effects can only be produced on nerves by strong currents; and also by the fact that the saline tissues of the swimming-bell must short-circuit any feeble electrical currents as soon as they are generated.

process, whatever it may be, a process of *physiological induction*, we may apply a similar name to a process which seems closely analogous to, if it is not really identical with, the process we are now considering. I refer to some highly remarkable observations which were published a year or two ago in Mr. Darwin's work on "Insectivorous Plants." It is there stated that, while looking at a linear series of excitable cells with the microscope, Mr. Darwin could observe the passage of a stimulus along the series, the protoplasm in the cells immediately stimulated first undergoing aggregation, then the protoplasm in those next adjacent doing the same, and so on. Now, the protoplasm in each cell was separated from the protoplasm in the adjacent cell by the walls of both the cells; yet, notwithstanding there was no observable anatomical continuity between these masses of protoplasm, a disturbance set up in any one of the series of masses immediately set up, by some process of physiological induction, a sympathetic disturbance in the immediately adjacent masses.

This, then, is one case that seems to be comparable with the case of physiological induction in the nerve-fibres of *Aurelia*, and I think it may be well for physiologists to keep awake to the fact that a process of this kind probably takes place in the case of these nerve-fibres. For it thus becomes a possibility which ought not to be overlooked, that in the fibres of the spinal cord, and in ganglia generally, where histologists have hitherto been unable to trace any anatomical or structural continuity between cells and fibres, which must nevertheless be supposed to possess physiological or functional continuity—it thus becomes a possibility that in these cases no such anatomical continuity exists, but that the physiological continuity is maintained by some such process of physiological induction as probably takes place among the nerve-fibres of *Aurelia*.

Before quitting the histological part of the subject, it is desirable to state that at about the same time as Mr. Schäfer's work was communicated to the Royal Society, two other papers were published in Germany on the same subject. One of these papers was by Messrs. Hertwig, and the other by Dr. Eimer. Both memoirs display a large amount of patient research, and describe the character and distribution of the nervous tissues in various species of *Medusæ*. These authors, however, do not describe the nervous network which has been described by Mr. Schäfer. I may add the interesting fact that the nervous tissues in *Medusæ* appear to be exclusively restricted to the body-layer which is called the ectoderm, and which is the structural homologue of that body-layer in which the nervous tissues of all the higher animals are known to have their origin during the life-history of the embryo.

Proceeding now to state some further results of various physiological experiments, I shall begin with the department Stimulation. And first to take the case of a physiological principle which I observed in the jelly-fish, and which has also been found to run through all ex-

citable tissues. If a single stimulation is supplied to a paralyzed jelly-fish, a short period, called the period of latency, will elapse, and then the jelly-fish will give a single weak contraction. If, as soon as the tissue has relaxed, the stimulation is again repeated, the period of latency will be somewhat shorter, and will be followed by a somewhat stronger contraction. Similarly, if the stimulation is repeated a third time, the period of latency will be still shorter, and the ensuing contraction still stronger. And so on up to nine or ten times, when the period of latency will be reduced to its *minimum*, while the force of the contraction will be raised to its *maximum*. So that in the jelly-fish the effect of a series of excitations supplied at short intervals from one another, is that of both arousing the tissue into a state of increased *activity*, and also of producing in it a state of greater *expectancy*. Now, effects very similar to these have been found to occur in the case of the excitable plants by Dr. Burdon-Sanderson; in the case of the frog's heart by Dr. Bowditch; and in the case of reflex action of the spinal cord by Dr. Sterling. Indeed, the only difference in this respect between these four tissues, so widely separated from one another in the biological scale, consists in the *time* which may be allowed to elapse between the occurrence of the successive stimuli, in order to produce this so-called summating effect of one stimulus upon its successor: the *memory*, so to speak, of the heart-tissue, for the occurrence of a former stimulus being longer than the memory of the jelly-fish tissue; while the memory of the latter is longer than that of the plant-tissue. And I may here add that even in our own organization we may often observe the action of this principle of the summation of stimuli. For instance, we can tolerate for a time the irritation caused by a crumb in our throats; but very rapidly the sense of irritation accumulates to a point at which it becomes impossible to avoid coughing. And similarly with tickling generally, the convulsive reflex movements to which it gives rise become more and more incontrollable the longer the stimulation is continued, until they reach a maximum point, where, in persons susceptible of this kind of stimulation, the muscular action passes completely beyond the power of the will. Lastly, I may further observe, what I do not think has ever been observed before, that even in the domain of psychology the action of this principle admits of being clearly traced. Who, for instance, has not felt it in the case of the ludicrous? We can endure for a short time, without giving any visible response, the psychological stimulation which is supplied by a comical spectacle; but if the latter continues sufficiently long in a sufficiently ludicrous manner, our appropriate emotion very rapidly runs up to a point at which it becomes incontrollable, and we burst into an explosion of ill-timed laughter. But in this case of psychological tickling, as in the previous case of physiological tickling, some persons are much more susceptible than others. Nevertheless, there can be no doubt that, from the excitable tissues of a plant, through those of a

jelly-fish and a frog, up even to the most complex of our psychological processes, we have in this recently discovered principle of the summation of stimuli a very remarkable uniformity of occurrence.

Hitherto light has never been actually proved to act as a direct stimulus to ganglionic matter. It is therefore of interest to note that it thus acts in the case of some species of *Medusæ*. *Sarsiæ*, for instance, almost invariably respond to a single flash by giving one or more contractions. If the animal is vigorous, the effect of a momentary flash thrown upon it during one of the natural pauses is immediately to originate a bout of swimming; but if the animal is non-vigorous, it usually gives only one contraction in response to every flash. That it is light *per se*, and not the sudden transition from darkness to light, which here acts as the stimulus, is proved by the result of the converse experiment, viz., placing a vigorous specimen in sunlight, waiting till the middle of one of the natural pauses, and then suddenly darkening. In no case did I thus obtain any response. Indeed, the effect of this converse experiment is rather that of inhibiting contractions; for if the sunlight be suddenly shut off during the occurrence of a swimming-bout, it frequently happens that the quiescent stage immediately sets in. Again, in a general way, it is observable that *Sarsiæ* are more active in the light than they are in the dark: it appears as though light acts toward these animals as a constant stimulus. Nevertheless, when the flashing method of experimentation is employed, it is observable that the stimulating effect of the flashes progressively declines with their repetition. The time during which the deleterious effect of one such stimulus on its successor lasts appears to be about a quarter of a minute. The period of latent stimulation is, judging by the eye, as short in the case of luminous as in that of other stimulation; but when the efficacy of luminous stimulation is being diminished by frequent repetition, the period of latency is very much prolonged.

The question as to what part of the organism it is which is thus susceptible of luminous stimulation, was easily determined by detaching various parts of the organism and experimenting with them separately. I thus found that it is the marginal bodies alone which are thus affected by light; for, when these are removed, the swimming-bell, though still able (in the case of *Sarsia*)[1] to contract spontaneously, no longer responds to luminous stimulation; whereas, if only one marginal body be left *in situ*, or if the severed margin, or even a single excised marginal body, be experimented on, unfailing response to this mode of stimulation may be obtained.

Responses to luminous stimulation occur in all cases equally well, whether the light employed be direct sunlight, diffused daylight, polar-

[1] In all the *naked*-eyed division of *Medusæ*, to which *Sarsia* belongs, total paralysis of the bell can only be obtained by removing the *entire margin*; but in all the covered-eyed division, to which *Aurelia* belongs, paralysis of the bell ensues on removing the *marginal bodies alone*.

ized light, or any of the luminous rays of the spectrum employed separately. On the other hand, neither the non-luminous rays beyond the red, nor those beyond the violet, appear to exert the smallest degree of stimulating effect. Hence, in all respects, the rudimentary eye of *Sarsia* appears to be affected by the same qualities of light as are our own.

Not so, however, in the case of another species of medusa, which I have called *Tiaropsis polydiademata*. This jelly-fish responds to luminous stimulation in the same peculiar manner as it responds to all other artificial—as distinguished from natural ganglionic—stimulation; that is to say, instead of giving a locomotor contraction of the bell, it throws the bell into a violent contraction of a long-sustained character, resembling cramp or tonic spasm. Now, in the case of this medusa, the luminous stimulation requires to act for a comparatively long time in order to produce a response. For, while in *Sarsia* the period of latent stimulation appears to be as short in the case of luminous as it is in the case of other modes of stimulation, in the case of *Tiaropsis* this is not so, although, as regards all modes of stimulation other than luminous, the latent period is as brief in the case of *Tiaropsis* as it is in the case of *Sarsia*. In other words, while this period is quite as instantaneous in the case of *Tiaropsis* as it is in the case of *Sarsia* when the stimulus employed is other than luminous, in response to light the characteristic spasm does not take place till slightly more than a second has elapsed after the first occurrence of the stimulus. Now, as my experiments on *Sarsia* proved that the only respect in which luminous stimulation differs from other modes of stimulation consists in its being exclusively a stimulation of ganglionic matter, we have evidence, in the case of *Tiaropsis*, of an enormous difference between the rapidity of response to stimuli by the contractile and by the ganglionic tissues respectively. The next question, therefore, is as to whether the enormous length of time occupied by the process of stimulation in the ganglia is due to any necessity on the part of the latter to accumulate the stimulating influence of light prior to originating a discharge, or to an immensely lengthened period of latent stimulation manifested by the ganglia under the influence of light.[1] To answer this question, I first allowed a continuous flood of light to fall on the medusid, and then noted the time at which the responsive spasm first began. This time, as already stated, was slightly more than one second. I next threw in single flashes of light of measured duration, and found that, unless the

[1] The period of latent stimulation merely means the time after the occurrence of an excitation during which a series of physiological processes are taking place which terminate in a contraction; so that, whether the excitation is of a strong or of a weak intensity, the period of latent stimulation is not much affected. The above question, therefore, was simply this: Does the prolonged delay on the part of these ganglia, in responding to light, represent the time during which the series of physiological processes are taking place in response to an adequate stimulus, or does it represent the time during which light requires to act before it becomes an adequate stimulus?

flash was of slightly more than one second's duration, no response was given. That is to say, the minimal duration of a flash required to produce a responsive spasm was just the same as the time during which a continuous flood of light required to operate in order to produce a similar spasm. From this, therefore, I conclude that the enormously long period of latent excitation in the case of luminous stimuli is not, properly speaking, a period of latent excitation at all ; but that it represents the time during which a certain summation of stimulating influence is taking place in the ganglia, which requires somewhat more than a second to accumulate, and which then causes the ganglia to originate an abnormally powerful discharge. So that in the action of light upon the ganglionic matter of this medusid we have some analogy to its action on certain chemical compounds in this respect—that, just as in the case of those compounds which light is able to split up, a more or less lengthened exposure to its influence is necessary in order to admit of the summating influence of its vibrations on the molecules; so in the case of this ganglionic material, the decomposition which is effected in it by light, and which terminates in an explosion of nervous energy, can only be effected by a prolonged exposure of the unstable material to the summating influence of the luminous vibrations. Probably, therefore, we have here the most rudimentary type of a visual organ that is possible ; for it is evident that, if the ganglionic matter were a very little more stable than it is, it would either altogether fail to be thrown down by the luminous vibrations, or would occupy so long a time in the process that the visual sense would be of no use to its possessor. How great is the contrast between the excitability of such a sense-organ and that of a fully evolved eye, which is able to effect the needful molecular changes in response to a flash as instantaneous as that of lightning!

Before leaving the case of luminous stimulation, I may observe that some of the *Medusæ* appear to be very fond of light. For, on placing a number of *Sarsiæ* in a large bell-jar in a dark room, and then throwing a beam of light through a part of the water in the bell-jar, the *Medusæ* all crowded into the path of the beam, and dashed themselves against the glass nearest to the light, very much as moths might do under the influence of similar stimulation. On moving the lamp round the jar, a cluster of *Medusæ* always followed it. This latter experiment is important, because it proves that the marginal ganglia are so far coördinated in their action that they can steer the animal in any particular direction.

Staurophora laciniata is a large species of naked-eyed medusa, which responds to stimulation in two very different ways, according as the stimulation is applied to the nervo-muscular sheet, or to the marginal ganglia. For, if the stimulation is applied to the nervo-muscular sheet, the response is an ordinary locomotor contraction ; whereas, if the stimulation is applied to the marginal ganglia, the response is a

tonic spasm of the same kind as that already alluded to in the case of *Tiaropsis polydiademata*. Now, it is a remarkable fact that into whatever form the bell of this medusa is cut—say, for instance, into the form of a long ribbon—whenever a locomotor contraction is started by stimulating any part of the general nervo-muscular sheet, it will pass all through that sheet, from end to end of the ribbon, in the form of an ordinary or gentle contractile wave. On the other hand, whenever a *spasmodic* contraction is started in the nervo-muscular sheet by stimulating any of the marginal ganglia, it will pass all through that sheet, from end to end of the ribbon, in the form of a spasmodic or violent contractile wave. Hence the muscular fibres of this medusa are capable of liberating this energy in either of two very different ways; and whenever some of them liberate their energy in one of these two ways, they determine that all the other fibres in the nervo-muscular sheet shall do the same. So that we may adopt a far-fetched but convenient simile, and liken the muscular fibres in this medusa to the fibres in a mass of gun-cotton. For in a mass of gun-cotton the fibres are likewise able to liberate their energy in either of two very different ways —viz., either by burning in quiet flame when they are simply ignited, or by exploding in a violent manner when they are detonated, as by a percussion-cap. And both in the case of the muscle-fibres of *Stauro-phora* and the cotton-fibres of gun-cotton, whenever any one of the whole number is made by appropriate stimulation (i. e., muscular stimulation or ignition) to liberate its energy in a quiet manner, then all the other fibres in the mass do the same; whereas, if any one of the whole number is made by another appropriate stimulation (i. e., ganglionic stimulation or detonation) to liberate its energy in a violent manner, then all the other fibres in the mass do the same. Now why the ganglia of this medusa should thus act as detonators to the muscular fibres, and why, if they do, the muscular fibres should be capable of two such different kinds of response—these are questions quite novel in physiology, and as such I will not endeavor to answer them.

Poisons.—As my space is now very nearly exhausted, I will conclude this article by very briefly stating the general results of a large number of observations concerning the action of various nerve-poisons on the *Medusæ*. It is easy to see that this is an important branch of the inquiry on which I am engaged; for in the nerve-poisons we have, as it were, so many tests whereby to ascertain whether nerve-tissue, where it first appears upon the scene of life, is of the same essential character, as to its various functions, as is the nerve-tissue of higher animals.

Chloroform, ether, morphia, etc., all exert their anæsthesiating influence on the *Medusæ* quite as decidedly as they do on the higher animals. Soon after a few drops of the anæsthetic have been added to the water in which the *Medusæ* are contained, the swimming motions of the latter become progressively slower and feebler, until in a minute or two

they cease altogether, the animals remaining at the bottom of the water, apparently quite dead. No form or degree of stimulation will now elicit the slightest response; and this fact, it must be remembered, is quite as remarkable in the case of the *Medusæ* as in that of any other animal. Recovery in normal sea-water is exceedingly rapid, especially in the case of chloroform and ether.

The effects of strychnia may be best observed on a species called *Cyanæa capillata*, from the fact that, in water kept at a constant temperature, the ordinary swimming motions of this animal are as regular and sustained as the beating of a heart. But soon after the water has been poisoned with strychnia, unmistakable signs of irregularity in the swimming motions begin to show themselves. Gradually these signs of irregularity become more and more pronounced, until at last they develop into well-marked convulsions. The convulsions show themselves in the form of extreme deviations from the natural rhythm of this animal's motion. Instead of the heart-like regularity with which systole and diastole follow one another in the unpoisoned animal, we may now observe prolonged periods of violent contraction, amounting in fact to tonic spasm; and even when this spasm is momentarily relieved, the relaxation has no time to assert itself properly before another spasm supervenes. Moreover, these convulsions are very plainly of a *paroxysmal* nature; for after they have lasted from five to ten minutes, a short period of absolute repose comes on, during which the jelly-fish expands to its full dimensions, falls to the bottom of the water in which it is contained, and looks in every way like a dead animal. Very soon, however, another paroxysm sets in, and so on—prolonged periods of convulsion alternating with shorter periods of repose for several hours, until finally death puts an end to all these symptoms so characteristic of strychnine-poisoning in the higher animals.

Similarly, without going into tedious details, I may say in general terms that I have tried caffein, nitrite of anyl, nicotin, veratrium, digitalin, atropin, curare, cyanide of potassium, alcohol, as well as other poisons; and almost without any exception I find them to produce the same effects on the *Medusæ* as they severally produce on the higher animals. The case of alcohol is particularly interesting, not only because an intoxicated jelly-fish is a ludicrous object to observe, but also because the experiments with alcohol show how precisely the specific gravity of the *Medusæ* is adjusted to that of the sea-water. For if, after a jelly-fish has become tolerably well drunk by immersion in a mixture of alcohol-and-water, it is transferred to normal sea-water, the exceedingly small amount of alcohol which it has imbibed is sufficient to make the animal remain permanently floating at the surface of the water until it again gets rid of the alcohol by osmosis.

As my space is now at an end, I must postpone for the present my account of a number of other experiments which, in point of interest, though not in point of systematic arrangement, have a better claim to

statement than some of those which I have now detailed. It is impossible, however, in one article to treat of all the new facts which have been yielded by this research; so that by making the present article dovetail with the one which was previously published in *Nature*, and also with future articles on the same subject, I shall hope eventually to lay all the results before the general public.—*Fortnightly Review.*

POPE AND ANTI-POPE.[1]

By Professor CARL VOGT,
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WHILE the political pope in Berlin and the clerical pope in Rome are trying to come to an understanding with each other, the controversy between the medical pope Virchow, of Berlin, and the zoölogical pope Haeckel, of Jena, is just beginning. First come speeches, then pamphlets, and very soon the heavy artillery of books will be brought into the line of battle, for such is the strategy of the learned and the tactics of the booksellers. The fray begins with Haeckel making a speech at the Congress of German Naturalists and Physicians at Munich; next, Virchow hits back at the same congress; then follows a sharp fire from the riflemen in the newspapers *pro* and *con*, according to the side they take; and, while this is going on, Haeckel sends into the field a pamphlet of one hundred pages, as a storming battalion. We have little doubt but that Virchow will answer with a volume twice as big, and this is all the more to be expected since, as it seems to us, the majority in this year's Congress of Naturalists (to judge from the speeches and lectures delivered at Cassel) leaned to the side of Haeckel. Then, too, the reception tendered to the two leaders in Paris, where Haeckel was lionized, while Virchow was treated not very kindly, will probably cause the latter to make another hostile movement.

Perhaps I ought to have entitled this article "Prophet and Schoolmaster," for, while Haeckel confidently advances with his hypotheses and phantasies, which he would fain palm off upon the public as "demonstrated truths," Virchow's manner is characterized by that schoolmaster air which is one of the prominent peculiarities of the Central Prussians, and especially of the Berliners. You cannot be in the company of a man of Berlin for a quarter of an hour without feeling that you are being corrected—in short, treated as a schoolboy; and the men of Berlin are surpassed in this respect only by the ladies. But, as in the two contestants, with whom we have here principally to deal, the sense of their own infallibility, which is the very note of the papal office, is specially prominent, and determines the whole tenor of their thoughts,

[1] Translated from the German by Gustav Miller.

the title given above may stand. True, it fares with their oracular allocutions and their *anathema maranathas* as with like utterances at Rome: though many bow their heads and blindly believe, still there are not a few doubters and unbelievers, and it is almost to be feared that the latter will form the majority.

The pith of the matter in dispute between these two men it is not difficult to get at: in short, it is Darwinism. Haeckel carries this theory to extremes; Virchow not only questions its legitimacy, but also insists that it may have applications that would imperil the state. The one wants to introduce the theory of evolution even into the schools, though, indeed, without knowing exactly how; the other would not only reject it absolutely, but he even anticipates Prince Bismarck by holding that Darwinism is in sympathy with democratic socialism; Haeckel tries to prove that the tendency of Darwinism is aristocratic rather; and, while Virchow sneers at the "souls of cells" and of "plastidules," Haeckel counters by affirming that these views are direct logical conclusions from the principle on which Virchow has staked his whole scientific existence, viz., that every cell originates from a cell (*omnis cellula ex cellula*).

I have already elsewhere expressed my views touching the quarrel fomented by Virchow, and have become only more satisfied of their correctness after reading Haeckel's pamphlet "Free Science and Free Teaching." While Haeckel has laid himself open to attacks by his exaggerations and by the brusqueness with which he has striven and still strives to impose his exceedingly poetical fancies upon others—a course of conduct which he will as surely regret later, as he now rues, according to his own confession, the "youthful extravagances" contained in his "Generelle Morphologie" and in his "Natural History of Creation;" while he makes inconsiderate and yet practical demands, without being clear about the possibility of their realization; nevertheless on the whole he represents truly the correct basis of freedom of science and of scientific teaching, so that one can without hesitation agree with his conclusions in that respect. Virchow, on the other hand, is the representative of the pedagogues' Philistia, which not only is proud of its ignorance, where ignorance is excusable, but which coolly denies everything that it does not understand, just as if it did not exist at all; and meanwhile appeals to the Church and to the police for aid against the practical application of scientific doctrines in the field of political action. Thus scientific research is to be free in the quiet of the study so long as there is no special statute to extinguish its lamp; but when it comes to the question of *teaching* science the situation is altered, and such a thing is not to be permitted save under restrictions.

Now, let us follow for a while the train of thought of Haeckel's counter-pamphlet. In the first chapter, entitled "Evolution and Creation," he compares the two theories, which, according to him, may be held concerning the origin of organisms, and, as I believe, of universal Nature:

Either organisms were evolved in a natural way, or they were created in a supernatural way, independently of one another. Haeckel, then, considers the evolution theory, first, as a universal cosmic idea, which assumes one causal law for all natural phenomena—the theory of descent, according to which all animals and plants are derived from simple primordial organisms; and, second, as the theory of natural selection (Darwinism in the strict sense), according to which the transformation of organisms has for its essential condition natural selection in the struggle for existence. And, by-the-way, we here find in Haeckel for the first time, if we are not mistaken, the admission that "the essence of the theory of descent is not affected, whether we postulate one or whether we postulate many common ancestral forms" (monophyletic hypothesis, polyphyletic hypothesis). It used not to be so, and whoever did not believe in the primordial mammal, the primordial amniote, the primordial fish, etc., was a lost man. In this admission we see the signs of a reaction from the monophyletic genealogies, which now fill whole volumes. Haeckel then tries to prove that Virchow is a believer in the creation theory, although he nowhere says as much openly. Virchow's expression, which Haeckel quotes, that "the scheme of organization within the species is immutable—like will beget like," is susceptible of more than one interpretation.

In the second chapter, entitled "Sure Proofs of the Theory of Descent," Haeckel rejects experiment as the highest means of proof, which Virchow requires; at the same time he asks: "What is there to be proved by experiments? What can experiment prove in this case?" But I must confess that I am not at all of his opinion. Haeckel is right in maintaining that the artificial breeding of our domestic animals, such as the horse, the pigeon, and the dog, and the culture of our garden-plants and culinary vegetables sufficiently demonstrate the mutability of species; that the forms purposely developed by us differ from one another far more than wild species do; that the evidence against the evolution theory, which was intended to be deduced from hybridization, is only empty talk, without sense, because several species do produce fruitful hybrids: but that the limits of experiment are here reached we can in no wise admit. Experiments like those made by Madame von Chauvin with salamanders can be repeated, not only with the lower vertebrates but also with the invertebrata, and must surely lead to very important results. I believe I can predict that the activity of working naturalists, as soon as the present rather artificial methods of hardening and dissection of organs and of whole animals, which reign now almost exclusively, shall have exhausted themselves, will be devoted to such experiments as have for their aim to prove that transformations, such as we see in Nature, can be produced at pleasure. To make this point clear, I will mention the eyeless cave-animals and parasites. To any one, however little familiar with the history of the evolution and the relations of these animals to others, they furnish a complete demon-

stration of the transformation of species once inhabiting open space and endowed with visual power into blind creatures with a very restricted range; but for men who, like Virchow, do not know these relations, the experimental proof might be given. Who will deny that such experiments would further science?

In the third chapter, "Cranium Theory and Ape Theory," Haeckel considers a familiar question, treated already by Virchow in a lecture delivered in 1869, on "The Crania of Men and Apes." Unfortunately, in regard to this very question, Haeckel has, by his extravagant theses, seriously weakened the ground on which he stands, if he has not swept it clean away. Once you say "Man is a true catarrhine monkey," then it is difficult to meet the swarm of objections that will be raised. Virchow's discourse was one of the weakest ever published on this subject, and, although the author directed his polemic chiefly against me, I have not seen fit to make any reply, because I should have had only to point out and meet a misunderstanding (whether intentional or not I will not decide) of what myself and others have said. Virchow himself, in that essay, declared that "the resemblance of young monkeys to human children is very much greater than that of old monkeys to adult and fully developed men;" but he is unable to see that this, and the fact that as they advance in age the differences become more pronounced, necessarily lead us to suppose a point of time in the remote past at which the two types developed in divergent directions. Haeckel, then, is perfectly justified when he says in his reply, "From this inevitable grouping results the *common* origin of man and monkey from *one* ancestral form;" and I observe with pleasure that here, again, Haeckel abandons his extravagant theses, and lays down propositions which must be regarded as entirely tenable.

Even if to me, as to Oscar Schmidt, Haeckel's doctrines concerning the "memory of the plastidules" and the "psychic activity of the cells" appear only as a "shipwrecked hypothesis," and not, as their author believes, "the sure foundation of empirical psychology," nevertheless, I must, on the other hand, admit that Haeckel simply demolishes Virchow's position in his fourth chapter on "The Cell-Soul and Cellular Psychology." That in the development of the psychic faculties of the organism we have the same process of perfectionment, the same division of labor, the same gradual differentiation, as in the development of the bodily organs and tissues, cannot be doubted; but when, at Munich, Haeckel asserts that we have in the several individual cells *the self-same* manifestations of psychic life, of sensation, and of thought (*Vorstellung*), of will, and of movement, which are seen in higher animals made up of many cells, he exaggerates; this exaggeration can, however, in part be accounted for by the fact that language possesses no terms to denote the obscure and in some sense *confluescent* expressions of these lowly psychic activities. But Virchow has the assurance to say to the assembled naturalists and physicians: "There is no doubt that, for us,

mental phenomena pertain to certain animals, not to the totality of all organized beings, nor even to all animals; this I maintain without hesitation. We have no reason yet to affirm that the lowest animals possess psychic attributes; these we find only in the higher animals, and with perfect certainty only in the highest." Verily, Haeckel is right when he says that any zoölogist, on reading this sentence, must throw up his hands in astonishment and ask, "Where would Virchow fix the point at which the soul suddenly enters the previously soulless body?"

But Haeckel deals his adversary a still more telling blow when, in the fifth chapter, "Genetic and Dogmatic Method of Teaching," he repudiates Virchow's theses touching the freedom of research and the restriction of the liberty of teaching. Virchow would have only objective knowledge taught in educational institutions. Haeckel, on the whole, only enlarges upon what I said in reply to Virchow eight months ago, when I gave to the Virchovian prescription this form: Give the student just so much as he requires to pass his examination and no more. As Haeckel justly observes regarding Virchow's suggestion that nothing should be taught which is not absolutely certain, all sciences, with the exception of lower mathematics, would have to be stricken from the lecture-list; and, as Helmholtz very properly remarks, it behooves us to declare that the teacher's work can never bear fruit, save inasmuch as it conveys to the student a conception of "how the thoughts of independent thinkers are moving."

The chapter entitled "The Theory of Descent and Social Democracy" is a brief one, because, as Haeckel tells us, the amazing denunciations pronounced by Virchow called forth from the moment of their publication the just indignation of thinking men, and were signally rebuked. It is a pity that Haeckel did not himself conform to the principle which he laid down toward the close of his chapter, where he says: "Wherein does all this concern the scientific investigator? His sole and only problem is this, to ascertain the truth, and to teach what he has recognized as true, without regard to what corollaries the various parties in state and church may draw from it." This was the right reply, nay, the only one, to make to Virchow's ill-judged utterance; but, instead of following it up, Haeckel endeavors to prove that the Darwinian tendency can only be aristocratic. A man can read in the book of Nature whatever he pleases, just as in the Bible; but Darwinism is neither socialistic nor aristocratic, neither republican nor monarchical; it is an explanation of the most diversified natural phenomena, but it rests on one simple principle. Such is Darwinism—nothing more, nothing less.

In the closing chapter, "Ignorabimus et Restringamur," Haeckel criticises Du Bois-Reymond and his speech made in 1872. Of this chapter we have only to say that we fully accept all that the author writes concerning the decline of natural science at the University of Berlin. How far ossification has advanced there, may be understood when we reflect that the chair once filled by Johannes Müller is to-day occupied by

Reichert. Formerly in Hesse the pay of parsons was attached to the cure. The result was, that good parishes always fell only to worn-out parsons, deserving, indeed, of promotion, but who could no longer render much service. Berlin is steadily approaching the same state of affairs. It is a pity that German universities cannot be dissolved every thirty years and manned anew! Perhaps some life would then flow into those places of refuge, where the scientific big-wigs rest from the toils of their youthful years!

SCIENTIFIC RELATION OF SOCIOLOGY TO BIOLOGY.[1]

By Professor JOSEPH LE CONTE.

I.

THE HIERARCHY OF SCIENCE.—There is a well-recognized scale in the hierachy of sciences. In the ascending order the steps are —mathematics, mechanics, physics, chemistry, biology, and geology. Mathematics deals only with space and time, number and quantity; and is therefore independent of matter and force. All other sciences deal also with matter and force, and are therefore properly called natural sciences, but they individually deal with different forms of matter and different grades of force. For example, the physical sciences deal only with those universal phenomena produced by physical forces; chemistry, in addition to these, deals also with a higher but more limited and special group of phenomena, determined by a peculiar force —chemical affinity; biology, in addition to all the preceding, deals also with a still higher and far more limited and special group of phenomena produced by a still more characteristic force—*life*.

The order of forces and phenomena-groups given above is, as we see, the order of increasing complexity and of increasing specialty, and therefore is also the order of their appearance in the evolution of the cosmos. There can be no doubt that physical forces and their associ-

[1] The views here presented were first embodied in the form of a lecture in 1859, and published in the *Southern Presbyterian Review* in April, 1860. They are now rewritten and condensed, the order of presentation entirely changed, and some new thoughts added. I mention this only to show that they are largely the result of independent thought—for they antedate the recent literature on the subject of sociology, as also Darwin's work on "Origin of Species." This re-presentation has been affected by Darwin's work only in one point, viz., the introduction of the principle of survival of the fittest. To two authors only I acknowledge large indebtedness. To Comte I am indebted for the general idea of a scientific connection between sociology and biology. To Agassiz I am indebted for a clear conception of the characteristic doctrines and methods of biology. In fact, all the *formal* laws of evolution, as now recognized, were announced by him, although he did not accept the origin of species by derivation. For the application of these laws to sociology, and for the mode of presentation, I am alone responsible.

ated phenomena appeared first, then chemical, then vital, and, lastly, rational (if these can be at all considered in the same category). It is also the order of dependence, and therefore, also, of historic development of the sciences based upon them. Mechanics is absolutely dependent on mathematics, and must, therefore, have awaited its development. Similarly, physics is dependent on both mathematics and mechanics, but especially the latter, and therefore must await its development. Similarly, chemistry must wait on all the preceding, but especially on physics; and biology must patiently await the development of all the preceding, but especially of chemistry.

But observe the following qualification: This is the necessary order in which these departments *take on true scientific form*, but not necessarily the order in which they are first commenced to be cultivated. Astronomy commenced to be cultivated by the Chaldeans long before mathematics or mechanics was sufficiently advanced to be applied to it. Biology commenced to be cultivated by Aristotle, or perhaps even by Solomon, long before chemistry and physics were sufficiently advanced to be of any use in biological investigations, and indeed before these sciences were born. In all sciences, but especially in the higher and more complex departments, there are three distinct stages of advance: The first consists in the observation, collection, and arrangement of facts—*descriptive science.* The second is the reduction of these to formal laws—*formal science.* Thus far the science is independent of other sciences. The third is the reference of these laws to the more general laws of a more fundamental science—in the hierarchy as their *cause—causal science.* It is this last change only which necessarily follows the order indicated above. Its effect is always to give great impulse to scientific advance; for then only does it take on the highest scientific form, then only does it become one of the hierarchy of sciences, and receives the aid of all. Thus to illustrate: Tycho-Brahe laboriously gathered and collated a vast number of facts concerning planetary motions—descriptive astronomy. Kepler reduced these to the three great and beautiful laws known by his name—formal astronomy. But it was reserved for Newton, by means of the theory of gravitation, to explain the Keplerian laws by referring them to the more general and more fundamental laws of mechanics as their cause, and thus he became the founder of physical or causal astronomy. In other words, astronomy was first a separate science based on its own facts. Newton connected it with mechanics, and thus made it one of the hierarchy. From that time astronomy advanced with increased rapidity and certainty. Astronomy first rose as a beautiful shaft, unconnected and unsupported, except on its own pediment. In the mean time, however, another more solid and more central shaft had grown up under the busy hands of many builders, viz., mechanics. Newton connected the astronomical shaft with the central column of mechanics, and thus formed a more solid basis for a yet higher shaft.

CHARACTERISTIC IDEAS.—Such, then, is the hierarchy of science and the mutual relations of the several orders. Now, each group of sciences, as Whewell has shown, has its own characteristic fundamental *idea* or *ideas*. For example, the fundamental ideas of mathematics—the ideas underlying all its operations—are those of *number* and *quantity*. The fundamental idea of mechanical and physical sciences is that of *physical force*. The fundamental idea peculiar to chemistry and underlying all its distinctive phenomena is that of *affinity*. The fundamental idea underlying all the distinctive phenomena of biology is that of *life*. Subordinate ideas under these general heads we shall call, after Comte, *doctrines*.

CHARACTERISTIC METHODS.—Again, each group of sciences has also its *characteristic method*. The characteristic method of mathematics is that of *notation*. We are all familiar with the wonderful power of this method. By the use of a few figures, viz., the numeral digits, having each a value of its own and another depending on position, a few symbols, a and b, x and y, connected by signs, $+$ and $-$ and $=$, the veriest schoolboy may quickly solve problems which would defy the unassisted efforts of the greatest genius. The characteristic method of physics and chemistry is *experiment:* without the use of this potent instrument these sciences could not advance a step. The characteristic method of biological sciences is the *method of comparison*. The use of this method we will illustrate after a while.

Now, each group, after it once enters the hierarchy, besides its own characteristic ideas and methods, uses freely and with the greatest advantage all the ideas and methods of the lower sciences, but especially those of the science immediately below, and with which, therefore, it is immediately connected. Thus chemistry uses the characteristic ideas and methods of physics and mathematics, but especially of physics. Biology, besides its own characteristic ideas and methods, uses freely the methods and ideas of chemistry—physics and mathematics—but especially those of chemistry. If there be any other still higher science, it must use with the greatest advantage the ideas and methods of all lower sciences, but especially those of biology.

Again: although the ideas and methods of the lower groups are imported into the higher groups and freely used there, yet we acquire clear conceptions of such ideas and doctrines, and expertness in the use of such methods, only in the group where they are native and characteristic. Thus, each group of sciences becomes the appropriate school for its own characteristic doctrines and methods. For example, physics uses freely the method of notation, but mathematics is the true school of this method. Biology uses experiment, but physics is the true school of this method. If there be any other still higher science which shall use the doctrines of life and the method of comparison, the cultivators of that science should first acquire clear concep-

tions of these doctrines, and learn expertness in the use of this method by the previous study of biology.

Now, there is, or shortly will be (for it is scarcely yet organized), a science far higher than any yet mentioned—a science which is the crown of human knowledge—a science to which all others are subsidiary—sociology. I wish to show the close connection between this science and biology. I wish to show that it only becomes truly scientific by being connected with biology, and thus placed at the head of the hierarchy. I wish to show that whatever of recent advance has been made in this science has been made by the application of the characteristic doctrines and methods of biology. I wish to show that biology is an important—yea, more, the most important—preparatory school for the study of sociology.

Biological Ideas applicable to Sociology.—As already stated, the fundamental idea of biology is life. Under this general idea there are two subordinate ideas or doctrines, viz., *organization* and progress by *evolution*. Life is maintained through an *organized structure*. Life advances from lower to higher grades by *evolution*. Now, is not society, too, endowed with life? Is not the social life maintained by organization; and does it not advance from lower to higher grades by a process of evolution? Let us examine in more detail:

1. *Organization.*—A living organized structure, or an organism, may be defined as a structure consisting of many different parts, having different forms, and performing different functions, but all coöperating to one given end, viz., the life, growth, and development, of *the whole*. The animal organism is composed wholly of cells, as a building is of bricks; all animal functions are performed by cells; growth is continual formation of new cells; reproduction is the separation of cells to form a new colony of cells. But the constituent cells of an organism, especially one of the higher organisms, are not all alike. On the contrary, they are as diverse in form as they are in function. The many functions of the body are parceled out among the cells by division of labor, and thus there results an absolute mutual dependence of parts. So society, also, is composed of many structural elements (individuals), having different pursuits, i. e., performing different social functions, and therefore mutually dependent, but all coöperating to maintain the life of the whole. Society, therefore, is in some sense an organism and subject to the laws of life and organization.

Again, as in the animal organism, the structural elements, the cells, are far more numerous than the functions: many cells of similar form aggregate to form *organs*, all the cells of one organ coöperating to perform its function, and all the organs coöperating for the life of the whole organism. So in the social organism, the structural elements (individuals) being much more numerous than the social functions, many individuals of like pursuits or functions aggregate into corporations, professions, trades-unions, etc. These are the organs of

the social body. They ought to coöperate for the welfare of the whole.

2. *Evolution.*—All the laws of evolution which have been discovered in organisms apply also to society, but with certain *limitations*, which I believe are very significant.

(*a.*) *Law of Differentiation.*—The most fundamental law of evolution is *differentiation.* The organism, as I have described it above, with its cells of diverse forms and functions, was not thus constituted in the beginning of its existence, but gradually became so by a process of differentiation. In the early stages of an organism the constituent cells are all *alike* in form, and each performs, though imperfectly, *all* the functions necessary in this early stage. But, as the organism develops, the cells begin to take on different forms, and to perform different functions, and this process of differentiation continues until, in the mature condition of the highest organisms, each group of cells (or each organ) is limited to the performance of one function only. This one function is its only evidence of life. Now, concurrently with this increasing differentiation of form and limitation of function, there is, of necessity, an increasing mutual dependence of parts, and a sacrifice of the independent life of the part to the common life of the whole. In the lowest condition of the organism, where the cells are all alike, and each performs, though imperfectly, all the functions, there is a very considerable, sometimes a complete, independent life in each cell; so that it may be separated without injury either to itself or to the community of cells: the independent life is large, the common life is feeble. But, as we rise in the scale of organization, the independent life of the part is merged more and more into the general life of the whole—is sacrificed, and goes to make up the common life—until, in the mature condition of the highest organisms, the independent life of the constituents is reduced to a minimum, while the common life is advanced to a maximum. This complete merging of the independent life of the part into the common life—this identification of life with function—is the *ideal of the animal organism:* the nearer it approaches this condition the higher manifestly is the organism.

Or take instead that larger organism, more nearly resembling, and therefore better illustrating, the social organism, viz., the *whole organic kingdom—its* present diverse condition has been reached also only by a process of differentiation. Commencing in the earliest times, with similar and independent beings, by a continual process of separation and differentiation, animal forms have become more and more diverse, occupying different places and performing different functions in the economy of Nature; the higher becoming still higher, and the lower becoming lower; the mutual dependence and interaction of all parts becoming greater and greater, until the ideal seems almost reached in the present fauna and flora. If we can conceive any organism still higher than man, or lower than the monera—if we can conceive a re-

lation and interaction between the different kinds constituting a fauna and flora still more complex, and a struggle for life still fiercer than now exists, then is the ideal not yet reached.

So society, also, has reached its present highly-organized condition only gradually, by a process of differentiation. In the early stages of society the constituent elements are all alike, and each performs, though in an imperfect manner, all the social functions necessary in this early condition. As society advances, the pursuits of man become more and more different, the social function of each more and more limited, until each is confined to *one* social function only. Concurrently with this differentiation of pursuits, the independent life of the constituents, absolutely perfect at first, is merged more and more into the common life of society, with increasing mutual dependence, as in the animal organism; and yet, alas! with increasing selfish antagonism and competitive struggle for life, as in the organic kingdom. Here, too, from the purely material point of view, the ideal, as in the animal organism, is complete loss of independent life—the complete merging of the individual independence into the common life of society—the identification of individual life with social function. Here, too, from the same point of view, the ideal, as in the organic kingdom, is the highest high and the lowest low, and the extremest diversity. The higher becomes the high, the lower sinks the low, and the more extreme the diversity—the more complete the loss of individuality and merging of constituent life into social function—the more perfect the mutual dependence, and yet the fiercer the antagonism and struggle—the nearer do we approach the ideal. This is manifestly the ideal of material organization, and therefore of society, from a purely material point of view. If this ideal is not only undesirable but impossible—if our whole better nature shrinks aghast from its realization—it is because it takes no cognizance of our higher and distinctively human nature, i. e., our spiritual or moral nature; it is because the law of our spiritual or moral is different and even antagonistic to the law of our animal or material nature. The relation of material units is by mutual dependence, and yet antagonism: the relation of moral units is by mutual sympathy and love. The existence of a moral nature limits the laws of a purely material organization. The essential difference, therefore, between the animal organism and the social organism is that, in the former, the constituents exist only for the community, while in the latter the community exists only for the constituents. This transcendent value of the constituents is manifestly the result wholly of the moral or spiritual nature of man.

There are, then, three stages of social advance: 1. *Gregariousness*, or loose, *unorganized* association of *similar* constituents: this corresponds in biology to the simplest form of cellular aggregation. 2. Gradually increasing differentiation and consequent merging of the constituent life into the common life by limitation of function, and

therefore mutual physical dependence, until the constituent life is finally identified with the social function: this corresponds with the *ideal* of material organization. 3. The *reassertion* of the independent personality of the constituents, and the alliance of these by *moral* instead of physical bonds—by mutual love instead of mutual dependence: this has no correspondence in material organization, since it becomes possible only through a higher nature than the material. There are, therefore, two modes of subordinating the individual life to the race—one by mutual dependence, the other by mutual love. The former destroys our personality, the second enhances it. He who loses his independent life by the first method, loses it irretrievably; he who loses it by the second method, shall find it again. The former is the ideal of material organization, and has been partially attained in many forms of society, ancient and modern; the latter is the ideal of Christian civilization. Society is even now in a state of transition between the two.

(*b.*) *Progress.*—The more fundamental law of differentiation limits, and in the minds of many persons confuses, the idea of progress. Progress as a law of evolution does not imply advance to successively higher points along every line and in every part; but only that the highest parts become successively higher, and the whole becomes successively greater. The constituent parts of a developing organism, starting from a common level, are some of them advanced to the dignity of brain-cells, and become the instruments of *thought*, while others sink to the condition of kidney-cells, whose function is only to secrete *urine*. But the highest cells become higher and higher, and the whole organism becomes greater and more complex.

Again, in the development of the organic kingdom, from the earliest geological times until now, if we could trace the several lines of genetic descent, we would doubtless find as many examples of retrograde as of advance movement. This fact has given rise to most of the dispute concerning the existence or non-existence of a law of evolution in the organic kingdom. This dispute is mostly the result of a misapprehension of the law of evolution. In the process of differentiation of the organic kingdom from a common level, the lines of descent went some upward, some downward, some sideways, every way and any way to reach some unoccupied place and subserve some different function in the economy of Nature, but the dominant classes became successively higher, and the whole organic kingdom successively greater and more highly organized. The tree of life sent its branches, some upward, some sideways, some downward, any way and every way for room and light, but its top went higher and ever higher, and its whole clustering branches became broader and ever broader.

So is it in society: if we could trace all the lines of genetic descent, starting from a common level, some would go upward, some downward, some this way and some that; in *social* function some would advance to the dignity of philosophic thinkers—the teachers of the race—and

some would sink to street-sweepers and sewer-cleansers. But the highest went progressively higher, and the whole became progressively grander. We are saved from the real as well as apparent degradation of these lower functionaries, only by the fact that the constituents cannot in the social organism, as they can in the material organism, be identified with and merged into their functions. Man has, fortunately, many other functions besides his *social* functions, viz., those higher functions connected with his moral nature.

In all progress, therefore, and as a necessary consequence of the law of differentiation, there is a straight and very narrow way, from the lowest to the highest, or ideal. Thus, in the progress of the organic kingdom from the lowest eozoön to the final term, the ideal, of material evolution—man—there is only one straight and narrow way onward and upward. Any turning off from that way leads, perhaps, to some other excellence, but not toward the highest—not toward man. Once leave the straight way, and there is no getting back upon it. Progress goes on, but only on the path chosen. The law, so far as material evolution is concerned, is inexorable. The tree of evolution has but one straight, ascending trunk leading upward to its terminal bud. A growing-point, once separated as a branch, continues, indeed, to grow, but only on its own way.

The same is true of higher forms of evolution. The progress of evolution of the organic kingdom, completed in man, is immediately taken up by man and carried forward on a higher plane in social evolution; and here, again, we find the same law. In the progress from primitive man to the condition of the most cultured races, there has been but one straight and narrow way. Those nations who by differentiation turned off from that track, have gone each their separate way—some this, some that—but cannot get back, or have not yet got back, on the true line of progress toward the highest. I do not say, however, that it is impossible to get back, for Reason again comes in to modify the material law and to confer plasticity on the nature of man.

The same law, again, appears epitomized with terrible significance in the history of each individual human soul. In the progress of the human spirit from childhood to the highest ideal of intellectual and moral culture—the Christian ideal—there is the same straight and narrow way. If we turn off from that way, it is easy to go on, but alas! how hard to get back! But for the modification of material laws by the presence of a higher law, it would be impossible.

(*c.*) *Cyclical Movement.*—In all evolution the progress which we have illustrated under the last head advances not at uniform rate, but in a succession of cycles by the rise, culmination, and decline, of higher and still higher dominant functions, principles, ideas, etc. Thus, in the individual human organism, there rise, culminate, and decline, first in childhood the *nutritive* functions; then in youth and early manhood, the *reproductive* and *muscular* functions; and, lastly, in full maturity,

the *cerebral* functions. Or, in the development of the mind, there rise, culminate, and decline, first in childhood, the perceptive faculties and the memory; then in youth and young manhood, the imaginative and æsthetic faculties; then in full manhood, or even beyond, the faculty of productive thought; and, finally, only late in life, and if the life has been noble, the moral and religious nature: the first, gathering and storing the materials for intellectual growth; the second, warming, vivifying, vitalizing, the materials thus gathered; the third, using them in constructive mason-work—in building the temple of science and philosophy; the last beautifying and ennobling that temple and dedicating it to holy purposes, thus connecting the evolution of the spirit in this life with that which, as we hope, continues in another. Similarly, in the development of that greater organism, viz., the organic kingdom, we have the rise, culmination, and decline of successively higher and higher classes of organisms: first of mollusca, then of fishes, then of amphibia, then of reptiles, then of mammals, and, finally, of man. And here, too, in the last step we find again the lower or animal evolution connected with and continued by a higher, viz., the social evolution.

So is it also in society. Here, too, we find progress is accomplished by a successive rise, culmination, and decline, of higher and higher dominant ideas or principles, determining different phases of civilization. The law may be traced not only in the general civilization of successive epochs, but even in the component parts or principles of civilization. It is not only cycle beyond and above cycle, but also cycle within cycle. Thus we have successively culminating and declining Egyptian, Greek, Roman, and now rising but not yet culminating, modern civilization, confessed by higher and higher forms. In natural religion we have everywhere first fetichism, then polytheism, and then monotheism. In the direct line of modern religious organization we have the Jewish and the Christian form. In the Christian Church we have the primitive or apostolic form, the Roman form, the Protestant forms, and we yet hope for a still higher and more rational form in the future.

But, observe: in all development, when a dominant function, faculty, principle, etc., declines, it does not perish, but only becomes subordinate to the next rising and higher dominant function or principle, and thus the whole organism becomes not only higher but also more complex. Thus, when the perceptive faculties and memory decline in early manhood, they do not perish, but only become subordinate to the higher dominant imaginative and æsthetic faculties characteristic of that age. Again, when these latter decline they do not perish, but only in their turn become subordinate to the still higher faculty of productive thought, which in its turn, and with it the whole character, becomes subordinate to the moral and religious nature. Thus the perfect man does not forget utterly the things of childhood and youth and early manhood, but

incorporates all that is best in each, and subordinates them to the highest; and thus the whole character becomes broader and more universal in its sympathies, as well as higher. This is the true type of culture—for culture is naught else than a natural evolution assisted by art. True culture does not educate us out of sympathy with childhood and youth, nor above sympathy with the lower classes of society; it does not simply raise us pygmies on a platform above the heads of our fellow-men, but without increasing our stature. If our culture does so, it is a false culture. The true cultured man stands on the same common level with other men, only his higher parts rise higher. But see the necessity which this law lays upon us of never-ceasing culture! Beautiful, joyous childhood cannot last, must decline. If we do not cultivate the higher imaginative and æsthetic faculties, our nature inevitably deteriorates from that time. Glorious youth and young manhood must decline, and with it our whole nature must deteriorate if we do not cultivate reflective and productive thought. Lofty intellectual power must also decline. Alas! how sad to see in old age the whole character deteriorate for want of moral and religious culture, which alone insures immortal progress!

The same law holds equally in the development of the organic kingdom. When the class of fishes declined in power, it did not perish, but became subordinate to the incoming higher dominant class of reptiles, which, in its turn, sought safety in subordination to the still higher incoming class of mammals, and this in its turn to the highest dominant class, *man;* and thus the whole organic kingdom becomes not only higher, but also broader, more complex, more diverse.

So, also, in society. When any dominant idea, principle, or social force of any kind, characteristic of any phase of civilization, declines, it does not perish, but becomes incorporated into the next higher phase of civilization as a subordinate force or principle. Thus each age incorporates what is best in the previous age, and modern society is the resultant of all the social forces which have acted from the beginning—is the heir of all the ages; and the social organism has thus become not only higher, but broader, stronger, and more complex. And here, again, the same necessity is laid upon us, of continuous progress or else of decline. No mere phase of civilization can last, no social force can continue in its pristine power. That nation which refuses to accept the incoming principle is left behind and inevitably decays.

Observe again: the speediness of the rise, culmination, and decline—the short-livedness—of any phase of civilization is in proportion to the limited character of the principles involved—the partialness of the embodiment of all the principles of our humanity. As society becomes more complex, its cycles become longer, until it reaches continuous, steady progress—immortality—only in the complete embodiment of an ideal humanity. Such we believe is the ideal of a Christian civilization.

Observe again: in all forms of development the culmination and decline are in *strength* rather than in *quality*. This is only another mode of expressing subordination to a higher force. The perceptive and imaginative faculties, indeed, decline in strength and vigor as age advances; but they steadily progress in refinement, if intellectual culture continues. If, for example, relish for art is more intense in youth, it is also more gross. If it declines with age, it becomes also more refined, more discriminating, higher—i. e., it becomes subordinated to higher faculties. The same is true of development of the organic kingdom; for, when a dominant class declines, it declines in *strength*, not in organization. So, also, is it in society. The principle of chivalry, for example, culminated in the middle ages. It has since declined in strength, but gained in refinement; lost in quantity, but gained in quality. It has become less fantastic, less extravagant, less affected; more rational and genuine. In other words, it has become subordinated to still higher principles.

Observe again and finally: this idea of progress of society by cyclical movement is comparatively modern, and even yet imperfectly apprehended. Whence did it come? We see no evidence of it among the ancient Egyptians, Greeks, or Romans, nor among modern Chinese or Japanese. None of these could conceive any civilization higher than their own. None of these dreamed of an onward progress of the whole race, of which their own civilization was only one temporary phase. The Jews had it not. They could not conceive of their religion and polity passing away. Is it to be wondered at, therefore, that they rejected Christ, who preached the unheard-of doctrine of the introduction of a new era? The idea was, in fact, first announced by Christ himself, when he taught that the Jewish polity and ritual must pass away, and *yet the law be fulfilled;* that the form is temporary, but the spirit eternal; that the form dies, but the spirit must take on higher and higher forms. Until that time it is doubtful if the idea of any scheme of religion or politics being a temporary phase of civilization, and therefore passing away by the very law of human progress—the idea that the forms of the social body like the forms of the animal body are necessarily temporary—ever entered the human mind. How imperfectly it is yet apprehended, even by the most advanced peoples, is plainly shown by the history of both church and state. Immutable forms have ever been asserted and maintained by force until violently broken and thrown off by revolution. This great law is now generalized and made a universal law of all evolution only by biological research.

(*d.*) *Survival of the Fittest.*—The survival of the fittest, in the fierce struggle for life, is the best known and most universally recognized factor of the evolution of the organic kingdom. The manner in which this factor operates especially in successive differentiation, and the increasing specialization of each differentiated form, in causing the

tree of life to branch and again branch continuously, each branch pushing its shoot as far as possible in its own direction, are well understood. The gradual but steady improvement, the strengthening of the blood, increasing the energies, sharpening the instincts by ruthless destruction of the weak, the slow, the dull, the unfit in any way, and thus adapting the remaining strong and active in the most perfect manner to the various and varying conditions of life, is also clear. This pitiless principle acts among animals *without limit* except in the case of the young of the higher animals, and its good effect is just in proportion to its pitilessness.

Now, in human society, also, the same principle must act and does act as a powerful agent of progress, *but not without limit.* There is here introduced a higher moral or spiritual law which limits and modifies the operation of the material law inherited from the animal kingdom—a law which seeks the survival and improvement of *all.* As animality gradually developed into humanity (if we accept this view), this new principle of benevolence and mutual help was added to the old principle of selfism and mutual antagonism inherited with the animal nature. A new principle of altruism (as it is now fashionable to call it) was added to the old principle of egoism, in small proportions at first, but gradually increasing in strength as humanity is developed. Under the influence of the Christian ideal this principle has become so active in modern society as to seriously impair the healthy operation of the more fundamental principle of the struggle for life. There is little doubt that the survival of the weak and helpless, and the sustentation of the unfit and the vicious, are beginning to poison the blood and paralyze the energy of the race. Also the survival of so many who would be eliminated by the operation of the old principle, increases the pressure of population on the means of subsistence, and thus also increases the evil. How shall we, then, settle the claims of these two opposite principles—the one necessary to the physical, the other to the moral improvement of the race? It is evident that Reason must hold the balance, adjust the equilibrium, and repair any damage which has already resulted. This she will eventually do by pointing out and enforcing simpler and more rational modes of life, by sanitary regulations, and by proper physical education. Thus will it gradually restore and increase the vigor of the race. It will undoubtedly also prevent the pressure of increasing population upon the means of subsistence by limiting reproduction by rational, healthy, and moral methods. I call special attention to this as another example of the limitation or even reversal of a purely material law by a higher law connected with our spiritual nature.

BLACK DIAMONDS.

By M. F. MAURY.

AS we sit by our firesides and peer into the glowing coals, or watch the bright jets of flame spring into existence to throw their cheery light into the room, making weird, fantastic shadows on the wall, and bringing with them such comforting cheer to our senses of sight and feeling, we are often brought into very reflective moods, especially if we are sitting in the twilight, while the cold wind is whistling, and the sharp snow and hail of winter are clicking against the windows. But how very few think, or care to know, whence comes this black substance that adds so much to the comfort and ease and luxury of life! Yet an account of its uses and its history and the story of its formation are instructive in the extreme, and as interesting as those two great subjects of the day—the telephone and the phonograph. Why the former excites so little comment, and the latter so much, can be easily explained, for we were born and raised with the blessings and comforts of the one, and they are of such every-day occurrence as not to excite attention; while the others, though less beneficial to the race, are so new and startling in their wonders, that they at once claim our thoughts and make us eager to learn of them and their progress.

There is no one substance in all Nature that has done more to ameliorate the condition of mankind, to build up the pride and strength of nations, to convert the world from barbarity to civilization, or add more to our ease and luxury, than this black and uninviting-looking mineral. Through its agency in producing the motive power for machinery in the steam-engine, the wild places of the earth are penetrated, men have ready and quick transit thereto, all the benefits of civilization flow in, cities spring up, the husbandman has facilities for sending his surplus produce to the markets of the world, and waste places are made to blossom like the rose. Those nations that possess it in the greatest abundance and purity are those that rise the most rapidly to the highest and mightiest positions; for it is the mainspring of all manufactures, and it carries the products of such to the consumers in distant countries, across the trackless waste of waters, with a certainty and speed unattainable by any other means; it enables nations to stretch forth their armies and navies with such promptness that insults are followed by speedy retribution, and invasion met or guarded against. The light for our homes and cities, the most beautiful and delicate dyes for clothing fabrics, and the ink that prints our books and papers to scatter knowledge through the world, all come from the products of its distillation. In all the power exercised by it, it works greater wonders than the magician's wand in the "Arabian Nights;" in its

beneficial effects to mankind, it may be said, like mercy, to shed its gentle dews from heaven; and, by being the prime cause of annihilating distances, it has brought the human race closer together, and is thus the "one touch of nature that makes the whole world kin."

It is not only the most useful but it is the most valuable of all minerals, on account of the wealth that is produced through its agency. It is well understood that money is a sequence of work, and a community that has small labor-bills can take the trade away from those that have to pay high rates. Let us, therefore, see what work this substance can produce.

In mechanics the unit of work is the power necessary to raise one pound one foot high, and this is known as a *foot-pound*. From numerous experiments and observations, an able-bodied man, in working ten hours a day, exerts an average force of 1,000,000 foot-pounds. When coal is burned under a boiler it produces steam, which in turn produces work as it drives machinery. Therefore, coal produces work, the amount of which will vary according to the perfection of the machinery and the appliances for generating the steam. If we take an average of all kinds of engines, one pound of coal will produce steam sufficient to exercise a power of 500,000 foot-pounds. Hence the work accomplished by two pounds of the fuel equals a man's day's work. Now, mark the surprising results to which this leads us. The population of the United States is about 40,000,000, and in 1877 we produced 50,000,000 tons of coal. If one-fourth of this were applied to manufacturing, etc., it would do as much work as our whole population, assuming them all to be able-bodied men, in 350 days. The coal at the engine will average about four dollars a ton, while the price of unskilled manual labor can be put down at one dollar a day. Applying these figures, we see that the work in the first case would have cost $50,000,000; while in the latter, were it even possible to employ so many men, the labor-bill would have been $14,000,000,000! Can any one for a moment question the advantage or the value of the substance?

In these days, accustomed as we are to its multitudinous uses, it is difficult to imagine ourselves in the position of the early writers, who touched with uncertain pen on what they thought to be the leading characters of a rare and ambiguous mineral, or to conceive that its introduction was accompanied by such prejudice and superstition that laws were actually passed forbidding its use by the very countries that now consider it as the greatest of their possessions. In fact, it is of comparatively late date that it has sprung into the important position which it now occupies.

The earliest express mention made of it as a fuel was about 300 B. C., in the writings of Theophrastus, the pupil of Aristotle, who speaks of it as being found in Liguria (now the province of Genoa) and in Elis on the way to Olympias, where it was used by smiths. *Ampelitis*, a black stone "like bitumen," is mentioned by Pliny as available for

medicinal purposes. It has been attempted to show that the ancient Britons used it, but there is no satisfactory evidence on the subject prior to the later days of the Roman occupation, and it is not until the thirteenth century that we obtain clear proof that it was systematically raised for fuel in England. In December, 1239, King Henry III. granted a charter for this purpose to the townsmen of Newcastle-upon-Tyne, and the coal soon found its way to London; but the complaints against it became so great, as it got to be more and more used, and the city more smoky, that in 1306, on petition of Parliament, "King Edward I. by proclamation prohibyted the burneing of sea coale in London and the suburbs to avoid the sulferous smoke and savour of the firing, and commanded all persons to make their fires of wood" (Stow). Nevertheless in about fifteen years it effected a lodgment even in the royal palace, for in 1321–1322, in the "Petitiones in Parliamento," a claim is made for ten shillings on account of fuel of that sort which had been ordered by the clerk of the palace, and burned at the king's coronation, but neglected to be paid for.

On the Continent of Europe the earliest coal known was in the tenth century, in the coal-basin of Zwickau in Saxony, but in 1348 the metal-workers of that town were forbidden to pollute the air with coal-smoke.

In England, in 1577, an old writer (Harrison), in contrasting the burning of coal in chimneys and of wood without them, alludes to this prejudice when he says: "Now we have many chimnyes, and yet our tenderlings complain of rewmes, catarres and poses; then had we none but reredoses, and our heads did never ake. For as the smoke in those days was supposed to be a sufficient harding for the timber of the house, so it was reputed a far better medicine to keep the good man and his family from the quacke or pose, where with, as then very few were acquainted. There are old men yet dwelling in the village where I remain, which have noted the multitude of chimnyes lately erected, whereas in their yoong days there was not above two or three, if so many, in the most uplandish towns of the realme, but each one made his fire against the reredose in the halle where he dined and dressed his meate." In 1632 the historian, Stow, remarks, that "within thirty years last, the nice dames of London would not come into any house or roome where sea coales were burned, nor willingly eat of the meate that was either sod or roasted with sea coale fire." In some parts of France the prejudice against the fuel extended even to within our own day—in 1840—for St. John, in his "Journal of a Residence in Normandy," mentions that Dr. Bennett, a Protestant clergyman, told him that "he had received orders to quit his house, *because he burned coal;* and another English gentleman at Caen, who had invited a large party, finding his drawing-room very thin, and inquiring the reason, found that the French had staid away *because it was understood he burned coal.*"

These latter, however, are isolated cases, for we see that its economy as a fuel gradually beat down prejudice and opposition, and the consumption steadily increased; but up to the beginning of the eighteenth century the only purpose for which it was used was for the production of *heat* in houses. It was now to enter upon its second grand phase of usefulness—that for the generation of *force*, as manifested through the agency of the steam-engine, which was first used for mining purposes. By this application of steam not only was the mining of the coal made cheaper, but the facilities for distributing it enlarged, and as engines were improved from time to time, their number increased, because they could be economically employed in a greater number of industries, and therefore the demand for this class of fuel rapidly extended.

About 1805 *light* established a new market and demand for the black diamonds. For a hundred years or more there were various experiments on the distillation of coal in order to produce tar and oils, while the practical application of the invisible gases that were set free was not thought of till 1792, when William Murdoch, engineer to Bolton & Watt, employed coal-gas for lighting his house and offices, at Redruth in Cornwall. The earliest application of this light, on a large systematic scale, was in Manchester, where an apparatus for illuminating the cotton-mills of Messrs. Phillips & Lee was fitted up in 1804 and 1805, under the direction of Mr. Murdoch. This new invention rapidly spread, and in 1807 public streets were thus lighted. During 1877 the gas companies in New York City and the immediate vicinity alone required about 450,000 tons.

At Coalbrook Dale, in England, between 1730 and 1735, Abraham Darby made successful experiments in substituting coal for charcoal, in the manufacture of iron, in the blast-furnace, and thus made the first step in an industry that now requires millions of tons annually; though it was not till 1830 that this trade really began to assume the gigantic proportions which it now has. At that date Neilson, in Scotland, applied the *hot-blast* to iron-furnaces, for the purpose of economizing fuel, and succeeded so well that a ton of coal now reduces three times as much iron as it did before. This, like all other inventions tending to economy, increased the manufacture of iron, and consequently demanded more fuel, exactly as the merchant finds it to his advantage to have quick sales and small profits.

During the last twenty years chemistry has discovered many minor but none the less striking applications of coal in utilizing the once waste products of its distillation for gas. Among these may be cited solid paraffin, which, when made into candles, equals in beauty those of wax; from its analine are obtained many of the most exquisite dyes, whose shades and tints please the eye and gratify our tastes; it seems almost past belief that some of the delicate toilet perfumes come from it, and that flavoring extracts to pander to our palates are distilled from the same black substance.

In America it is remarkable that the first discovery of this mineral, of which we have any written record, should have been made as far in the interior as Illinois. It is mentioned by Father Hennepin in 1669, when he found the outcrop of a seam on the Illinois River, where the town of Ottawa now stands. The first that came into use, however, was that from Virginia, near Richmond, which for a long time supplied the whole Atlantic market. Anthracite (of which we produced over 21,000,000 tons in 1877) had quite a struggle to obtain a footing, as its value and use were not known; in fact, the first Lehigh coal sent to Philadelphia in 1803 was considered worthless, and was broken up to be used on the sidewalks.

In the early days of this country, wood was so abundant and cheap, and the means of transportation from the interior so limited, that the demand for fossil fuel in the United States could be met by a few thousand tons a year. We have no accurate record of the tonnage which *was* produced, but it was about 1,600 tons of anthracite and about 80,000 tons of bituminous in 1820, which was one ton to every one hundred and twenty persons of the population. As the country was settled, railroads built, furnaces erected, and steam and machinery came into greater and greater use, the demand increased, until in 1877 the production was one and a quarter ton to every man, woman, and child of the Union—or 50,000,000 tons. The vast quantity represented by these figures can be better brought before the mind by stating that, if this amount were packed in a *solid* mass, it would make a wall from New York to Washington—two hundred and forty miles—ten feet wide and eighty-five feet high; while, if it were put together in the broken state in which coal is commonly used, the wall would be one hundred and sixty-one feet high. This tonnage places our country as the second coal-producer in the world, Great Britain being first, with an output in 1877 of about 130,000,000 tons.

From what has been said regarding the power and wealth that this article bestows, the following table shows that the American Union has a most magnificent future prospect, as it is destined to become the great fuel-producer of the earth; and that not only because of the vast area of its coal-fields, but because of the thousands of square miles wherein the seams are so easily accessible to the miner; as they often lie either above water-level or at very moderate depths, thus obviating the expense of deep and costly shafts to reach them, and this is a very great advantage. "So immense indeed are the riches of the American coal-measures that, in their conception of the future development of mankind, geographers, historians, philosophers, agree in the idea that the United States have, especially in their coal-deposits, the elements for the greatest and most perfect development of the human race" (Lesquereux).

COUNTRIES.	Area of Coal-fields in Square Miles.	Percentage of Total Area.
United States	192,000	73.85
Nova Scotia	18,000	6.90
Great Britain	11,900	4.60
Spain	3,000	1.20
France	1,800	0.70
Prussia	1,800	0.70
Austria	1,800	0.70
Belgium	900	0.35
Chili, Australia, India, China, etc.	28,800	11.00
Totals	260,000	100.00

And now for the story of how this wonderful mineral was formed. It is one of the well-established facts of geology that it is of vegetable origin. This is not simply a theory, for in Nature coal can be seen in various stages of formation where vegetable tissue is heaped up and accumulated in bogs. As we dig down into these bogs where the woody matter is surrounded by moisture, and in a favorable position for slow decomposition, it is seen that it is transformed into a dark, combustible compound which is first called *peat;* then, as it becomes harder and more changed, *lignite;* while the oldest peat-bogs in Europe have, at or near their bottom, thin layers of hard, black matter that neither examination by the eye nor analysis by the chemist can distinguish from true coal, and which, therefore, must be true coal. "In Holland, Denmark, and Sweden, the thick deposits of peat are separated into distinct beds by strata of sand and mud, giving the best possible elucidation of the process of stratification of the coal-measures" (Lesquereux). For their formation these bogs require a basin rendered impermeable by a substratum of clay and an active growth of aquatic or semi-aërial plants, having their roots in water, while their branches and leaves expand on the surface thereof, or rise in the air above it, constantly growing in the same place, whose *débris*, falling year after year, is heaped up and preserved against atmospheric decomposition by stagnant water or great humidity in the air. It was during the Carboniferous epoch, when our principal and most valuable seams of coal were deposited, that all these favorable circumstances were in their highest development. For a dense vegetation we also want a warm, moist, and equable climate, and air more or less charged with carbonic-acid gas, as that is the food of plants (just as the oxygen gives life to man), though it is poisonous to warm-blooded animals, it being impossible for such to live in an atmosphere containing more than about one per cent. of it.

During the Carboniferous age of the earth's history the water covered very much more of area than it now does, and portions of the continents were so little raised above its surface that a slight elevation or depression would change them from marshes and lagoons into dry land, or sink them below the surface of the sea. When air passes over, or rests on, oceans, or lakes, or rivers, etc., it becomes laden with vapor,

whose influence is very potent, as its power of absorbing and retaining heat is thousands of times greater than that of air. Hence, as the ocean was so largely preponderant, there was an atmosphere heavily charged with moisture, which in time was favorable to a warm and equable climate. In fact, the want of annual rings in carboniferous plants proves that there was no winter, and, as the same coal-plants grew at the same time in Europe and America, the same climate must have prevailed. The air was also charged with carbonic acid, for there are no fossils (which Prof. Huxley so beautifully says are the labels that an Almighty hand has put upon the specimens in Nature's museum) in this or any other earlier formation of warm-blooded animals.

In all these circumstances, therefore, there exist the most advantageous conditions for the rapid and continuous growth of vegetation, and, judging from the fossils thereof, it must have gone on with a density and luxuriance that wellnigh surpasses conception. Floating vegetables first made their appearance, spreading their branches and leaves on the surface of the water, and filling the basin or lagoon with their *débris*, thus forming a support for the more aërial vegetation, compared with which anything in our day of the same species, in respect to size and quantity, fades into insignificance.

The exuberant growth of the tropics is astonishing to us; but it is as nothing when we contemplate that of the coal era. For example: *Equisetum*, the horse-tail flag, with us is never more than half an inch in diameter, while in the coal-rocks gigantic reeds of this kind were as much as fourteen inches in diameter. Living club-mosses, even in our tropics, attain no great height, but there they were as thick as a man's body and sixty and seventy feet high. Our ferns are of insignificant size, but in those olden days they raised their feathery foliage to a height of sixty feet and upward. There are others that grew to the same wonderful proportions; and as they fell others sprang up, and thus the "heaping" process continued until Nature caused some subsidence of the ground; the water closed over it all, and the currents deposited mud and sand upon it: if the former, a stratum of slate was the ultimate result; if the latter, a stratum of sandstone. When this subsidence ceased, fresh growths sprang up and a new deposit was formed, to sink and be covered in its turn; and as often as these periods of rest and submergence were repeated, so often did a new coal-bed come into existence, and in this is a simple rational explanation why the coal-measures have more than one seam in them.

If, on the other hand, an elevation took place, the roots of the plants were deprived of their moisture, and they not only ceased growing and the deposit accumulating, but the rains and surface-drainage gradually eroded the latter away, and, as it floated off, it became mixed with any earthy matter which the waters may have had in mechanical suspension; and, when it was finally deposited in some lagoon or overspread other formations, it ultimately made an inferior coal, or a black

slate, according to the preponderance of the mud which was with it. Thus we can understand one of the causes why some regions have more seams than others.

When the deposit was covered up, as before explained, a gradual decomposition took place, which consisted in an evolution of a portion of the carbon, and most of the hydrogen and oxygen, in the form of water and gases from the woody tissue, leaving a larger and larger percentage of the carbon of the plant behind, while the increased pressure of the accumulating strata above served to compress and solidify the mass. But before this solidification took place, as Liebig has proved, by direct experiment in the process of slow decomposition of vegetable matter in water, a softening occurred, and it is to this that we must ascribe the fact that no delicate fossils are ever found in the coal itself, as the tissue and form were destroyed by the softening and subsequent pressure, though cases are met with where solid trunks of trees have resisted this softening process, and are found standing erect in the seams while their roots are plainly traced in the clay-slate below. In the slates above and below, which, it must be remembered, were originally soft, plastic mud, the plant-impressions, however, are as sharp and clear as though they had been sketched with an artist's pencil.

The formation of different kinds of coals, such as anthracite, semi-anthracite, semi-bituminous, and the many different varieties of bituminous, is supposed to be owing to the different degrees of progress made in the process of softening and carbonization, and to there having been freer escape for the gaseous constituents in some cases than in others. Chemists have actually converted vegetable matter into coal of all degrees of hardness, and possessing all the various qualities of that formed by Nature, and observation and their labors seem to show that all coal was first formed of the bituminous variety, and that anthracite is the result of igneous action to which it was subsequently subjected (MacFarlane). When this change has been carried still further, the result is plumbago, or black-lead.

I have thus endeavored to set forth in a plain, comprehensible manner the theories of the formation of our fossil fuels, and, while difficulties may suggest themselves to the reader, still that they are derived from the vegetable kingdom admits of no doubt, this being one of the well-established facts of geology.

There is one more benefit that coal has been the cause of bestowing upon mankind that is as striking as all those previously set forth, to which I would call attention before closing. The Bible tells us that the beasts of the field and the fowls of the air were not created until after the earth brought forth grass, the herb yielding seed, and the fruit-tree yielding fruit after his kind; and with the aid of science we can see a reason for this. It has been stated that one of the requisites for the vegetation of the coal era to flourish as it did was that the atmosphere should be charged with a compound of carbon and oxygen known as

carbonic-acid gas, and that this gas, except in very small proportion, destroys life in warm-blooded animals. It was the tree that drank in the noxious vapor through its leaves, decomposed it, took of the carbon to add to its stature, and to yield seed and fruit after its kind, while it breathed the life-producing oxygen back into the air, and in this way the atmosphere was purified for the use of man and beast.

Thus in the economy and wonderful working of Nature not only was this gas, that precluded life, removed, but it was stored up for the future use of that same life that its removal made possible, so that coal, besides giving light and warmth, and a thousand other material blessings, was the prime cause of the very air we breathe. Surely it is, and it has been, a wonderful and blessed boon to the earth and its population, and it is of no wonder that it has been given the name of the most costly gem we know when it is called black "diamond."

THE DEVIL-FISH AND ITS RELATIVES.[1]

By W. E. DAMON.

PERHAPS no better introduction to this chapter can be given than to recall to the minds of our readers the terribly vivid description of the devil-fish by that grand master of romance, Victor Hugo; for, though incorrect in several scientific details, the general description is the best we have had, though Jules Verne's is almost as dramatic and nearer to Nature.[1] In "Les Travailleurs de la Mer" M. Hugo says: "To believe in the existence of the devil-fish, one must have seen it. Compared to it the ancient hydras were insignificant. Orpheus, Homer, and Hesiod, *imagined* only the chimæra—Providence *created* the octopus. If terror was the object of its creation, it is perfection. The devil-fish has no muscular organization, no menacing cry, no breastplate, no horn, no dart, no tail with which to hold or bruise, no cutting fins, or wings with claws, no prickles, no sword, no electric discharge, no venom, no talons, no beak (?), no teeth. It has no bones, no blood, no flesh. It is soft and flabby, . . . a skin with nothing inside of it. Its under surface is yellowish; its upper earthy. Its dusty hue can neither be imitated nor explained; it might be called a beast made of ashes which inhabits the water. Irritated, it becomes violet. It is a spider in form, a chameleon in coloration.

"Seized by this animal," he adds, "you enter into the beast; the hydra incorporates itself with the man; the man is amalgamated with the hydra. You become one. The tiger can only devour you; the devil-fish *inhales* you. He draws you *to* him, *into* him; and, bound and

[1] From "Ocean Wonders." in the press of D. Appleton & Co.

helpless, you feel yourself slowly emptied into this frightful sac, which is a monster. To be eaten alive is more than terrible; but to be *drunk* alive is inexpressible!"

This overwrought but wonderfully dramatic description (but a small part of which we have quoted) at once excited a popular interest in the habits and history of the octopus, though it was well known and described by Aristotle before the Christian era. Moreover, the animal so

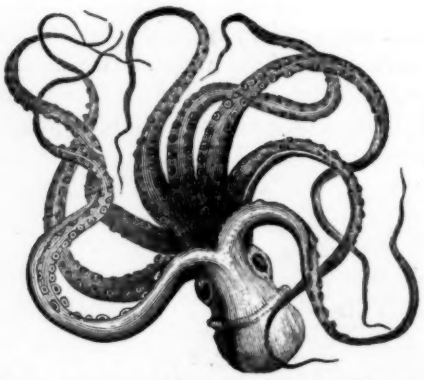

FIG 1.—OCTOPUS OR DEVIL-FISH (*Octopus vulgaris*).

graphically pictured by the novelist was a mere "baby devil" in comparison with many which exist, and which have been described by that enthusiastic naturalist, Prof. Verrill, of Yale College.

In a letter addressed to me on this subject by Prof. Spencer F. Baird, under date of April 1, 1878, this distinguished naturalist says: "The giant squid in the New York Aquarium can only be designated as an infant or dwarf in comparison with the gigantic species of the Pacific Ocean—those upon which the sperm-whale is known to feed. Chunks of squid-remains are not infrequently found in the throat or stomach of the sperm-whale, apparently indicating specimens from ten to fifty times the size of the Newfoundland variety. I was informed that a considerably larger specimen than that at New York was cast ashore at Newfoundland later in the season. The arms of the latter, if I recollect right, were some ten feet longer than those of the other."

The specimen referred to by Prof. Baird, as at the public aquarium in New York, is of the species known as *Architeuthis princeps*. It measures about forty feet, and is preserved in alcohol. I have in a bottle some specimen portions of the sucking-disks, showing the serrated edges, from the arms of this terrible animal; and I have also a perfect specimen of a smaller species of the animal itself in my private collection.

Prof. Verrill's reports apply to the devil-fish found in our northern seas, and Prof. Baird mentions those cast ashore at Newfoundland; but

that they are not limited to the northern waters is certain. The late Captain Frederick Reimer, of New Jersey, a very intelligent observer, who was in Beaufort Harbor, North Carolina, in 1862, described one that he saw there which measured fully thirty feet in length. Any one who has seen the specimen captured at Newfoundland can readily conceive how such a monster could stretch out its two long arms and seize its prey. These arms together form a pair of powerful pincers at their extreme ends, and are furnished for their whole length with two rows of

FIG. 2.—THE GIANT SQUID.

perfect sucking-disks, or some two thousand air-pumps; the edges are also cut into sharp, saw-like teeth, as hard as steel, and these are buried in the flesh of its prey. With all these appliances it could easily reach a distance of twenty-five feet, and bring the body of a man to its mouth,

where, with its powerful iron-like beak, it crushes the helpless form, and swallows or *drinks* it down, as Victor Hugo says.

My own experience with these creatures has been principally in the Bermudas. They are there caught in basket-traps, formed of wood. With a trap baited with mussel, crab, or lobster, of which the octopus is particularly fond, we row along the island-shore, among the more rocky parts, until we discover some indication of the animal's retreat. Their hiding-places can only be discovered by experts, but one of the trails by which they are traced is the presence of dead shells in unusual quantities, particularly skeletons of crabs, which will be pretty certainly seen near the water's edge, or at the mouth of the cave inhabited by a "devil." The clearness of the waters greatly aids in the search. When a promising location is reached, we throw overboard the trap, which sinks to the bottom of some ledge, or rests upon a reef of coral. A rope, which is attached to it, is secured to a buoy to mark its place on the surface of the sea, and it is left for twenty-four hours. Then we return and haul it up, and, if the place of deposit has been well chosen, we shall soon see the long arms of Mr. Devil protruding through the basket, searching and stretching in all directions, seeking to understand how it is that positions have become so reversed —that he is the captured instead of the capturing party. His color changes with anger and vexation, and his body then displays numerous bunches or tubercles, which always appear when the animal anticipates danger.

The trap being opened, we seize him quickly by what we must call neck, the portion between the head and trunk, while his eight arms or legs, as you may choose to call them, are struggling and twisting in all directions, sometimes becoming attached to our own arms and twin-

FIG. 3.—AN OCTOPUS RUNNING.

ing about them. Those which I caught and handled had arms of remarkable softness and suppleness, so that their contact felt more like a running liquid upon my flesh than a structural substance;[1] and, indeed, though so formidable under certain circumstances, the preponderance of fluidity in their composition may be judged from the fact that I my-

[1] This lack of tension probably resulted from my pressure upon the neck.

self saw one, which measured three feet in length by five or six inches in width, sqeeze or *run* itself through a crevice not over *half an inch* in width!

I should have mentioned that if it is desired to preserve the octopus alive, the pressure on the neck should not be too severe, for that is their vulnerable point; and a person attacked by one should never lose time in striving to loosen its arms, but grasp if possible this portion connecting the head and body, in which way they may be easily killed.

In regard to their powers of locomotion upon land, on which there has been considerable controversy, I can assure the reader that I have seen a full-grown octopus at the Bermudas spring up out of the water, only a few feet forward of the boat I was in, and run up a perpendicular rocky cliff for more than *two hundred feet!* This ledge of rock bore a general resemblance to our Hudson River Palisades at their steepest portion. We soon learned the cause of this seemingly strange performance, when we discovered one of those beautiful bright-red crabs, which are native to the locality, trying to escape from the clutches of this devil-fish. The crab, being frightened almost out of its simple wits, had run up the rocks for safety; but its tactics proved sure death in the end. As to the speed of the octopus, it appeared to me to travel much faster than I could run. At least, I should not care, if unarmed, to engage in a race with one, unless Mr. Devil started a good way *ahead*.

In this case I soon came into closer acquaintance with our agile friend, for the next morning I had the satisfaction of discovering that he had walked into our trap, which we had carefully placed near his cave; and now that we could see him face to face, we found that his strength was enormous as compared with his moderate size. Being placed in a bucket of water, such as is usually found on a ship's deck, he attached his eight arms to the bottom and sides, by means of his powerful and perfect-working suction-disks, so firmly, that I several times lifted the bucket, water and all, by taking hold of the animal's body, and twirled it over my head. The more I twirled the more firmly it stuck. An octopus will not relax its hold "on compulsion," any more than Falstaff would "give reasons." It is as self-willed as some human animals.

FIG. 4.—PEARLY NAUTILUS (*Nautilus pompilius*), showing chambers inside of shell.

According to scientific classification, the octopus belongs to the division of soft-bodied *Mollusca*, and the class of *Cephalopoda*—mean-

ing "feet proceeding from the head." Of these the octopus, as its name indicates, has eight feet, or arms; for, though these long appendages are sometimes used as feet, they are habitually used as arms.

Of the octopoda family is the small paper nautilus or argonaut. How few of our readers who have admired this beautiful shell, with its mother-of-pearl lining, have realized that its former inhabitant was own cousin to the horrible devil-fish!—a female cousin, we must add, for the shell is not connected with the animal organically, but is held in position by two of the long arms, with the sole purpose of protecting the eggs. The male argonaut has no shell.

Though all the octopods, large or small, can swim freely at will, such is not their habit; they prefer to lie concealed, or partially so, on

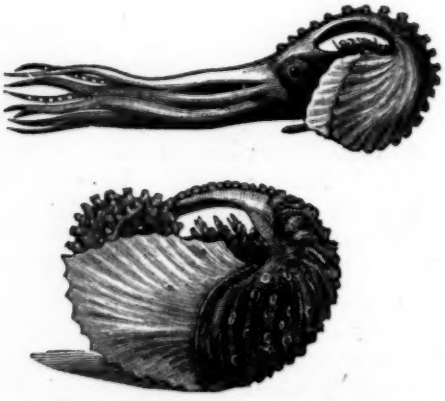

FIG. 5.—PAPER NAUTILUS (*Argonauta argo*).

the side or in the clefts of rocks. There the octopod's body is protected from the attacks of other animals, while it can extend its long feelers in search of prey, of which fish, mollusks, and crustaceans, are the principal objects. Its movements, when an object of food is perceived, are marvelously rapid, swifter than the flight of an arrow from the bow of an experienced hunter. The long, flexible arms grasp the victim; its hundreds of suckers, acting like pneumatic holders, make escape impossible; and, as the long arms draw the object nearer and nearer, the other shorter arms add their multiplied disks, forming "a perfect mitrailleuse of inverted air-guns, which take horrid hold, and the pressure of air is so great that nothing but closing the throttle-valve can produce relaxation." This throttle-valve is the neck, as we have before described. Those lengthy appendages, the limbs, are rather in the way when the animal is swimming, and would act as drag-anchors if left pendent; but the octopus usually draws them close alongside, whence they extend in an horizontal position, acting the part of a tail to a kite. It propels itself by drawing in and expelling water through its locomotory tube.

The octopus swims backward, and it has been remarked that it changes its color to a darker hue when it starts out for a swim.

This change of hue, apparently at will, is one of the most peculiar characteristics of the octopus. It may be considered the chameleon of the sea. Its ordinary color when in repose is a mottled brown; but if irritated it assumes a reddish hue, approaching to purple. Nature seems to have been almost superfluously careful in furnishing this animal with protecting elements; for this coloring-matter, which resides between the inner and outer skin, enables it even to assume the color of the ground or rocks over which it travels, so that one can hardly say what color it is before it may have changed to something quite different. When exhausted after a battle or a struggle to get out of a trap, it turns pale, like a human being.

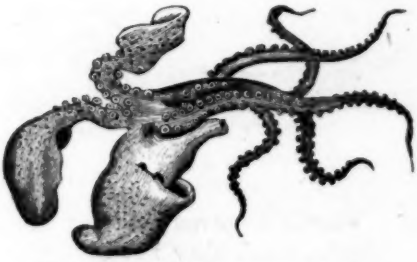

FIG. 6.—ARGONAUT WITHOUT THE SHELL.

Others besides Victor Hugo's hero have had a chance to test the strength of these devil-fishes. Major Newsome, R. E., when stationed on the east coast of Africa in 1856–'57, undertook to bathe in a pool of water left by the retiring waves. He says: "As I swam from one end to the other, I was horrified at feeling something around my ankle, and made for the side as speedily as I could. I thought at first it was only sea-weed; but as I landed and trod with my foot on the rock, my disgust was heightened at feeling a fleshy and slippery substance under me. I was, I confess, alarmed; and so apparently was the beast on which I trod, for he detached himself and made for the water. Some fellow-bathers came to my assistance, and he was eventually landed. . . . As the grasp of an ordinary-sized octopus holding to a rock is not less than thirty pounds, while the floating power of a man is between five and six pounds, I believe if I had not kept in mid-channel it would have been a life-and-death struggle between myself and the beast on my ankle. In the open water I was the best man; but near the bottom or sides, which he could have reached with his arms, but which I could not have reached with mine, he would certainly have drowned me."

The major was right; he had every chance of sharing the fate of the immortal Clubin.

When a crustacean casts a limb from its junction with the body, it is after a time reproduced; if injured below this point, it has no recuperative power. But our "devil-fish," which really seems favored beyond its deserts, will reproduce any injured portion of its arms, at whatever point they may have been severed; of the numerous specimens which have been scientifically examined, many showed that one, two, or more arms have been either repaired or reproduced; and some of the female specimens have shown a loss of the whole eight arms, but all more or less restored.

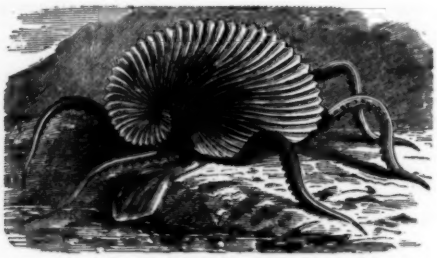

FIG. 7.—ARGONAUT WITH THE SHELL.

Another kind of exuviæ observed with the octopods is the outer skin of their long limbs, which they not infrequently shed. These cast-off skins float upon the water, and are one of the indications which lead to the discovery of their retreats. When the outer skin becomes too tight for the growing animal, or is worn too smooth by frequent contact with the rocks, the creature may be seen rubbing its arms against each other as if they were undergoing a scrubbing or cleansing process, and soon these thin, filmy skins may be seen floating away on the surface of the water.

At certain periods there appears in the male octopus what is called the *hectocotylus* development in one of the arms. When this gentleman would a-wooing go, as Mr. Lee says in his valuable little book on this subject, and "he offers his hand in marriage to a lady octopus, she accepts it most literally, *keeps it, and walks away with it;* for this singular outgrowth is detached from the arm of the suitor, and becomes a separate living creature," specimens of which have been preserved in the Museum of Natural History in Paris. This *hectocotylized* arm is afterward reproduced in the male.

It is surprising with what care the female watches over the development of the eggs. Having selected a snug retreat in the rocks, she will barricade it by dragging to the entrance other portions of rock, or perhaps a pile of oysters—anything out of which she can make a strong breastwork or line of defense; and then she sits on guard ready to attack any intruder, even though it be her own mate. The eggs when first laid are about the size of grains of rice, and are arranged upon a

stalk which is attached to the rock by a cement secreted by the parent, and to which each egg is separately attached, like a mass of bananas on its stalk, only much more closely packed, the number being immense; an octopus will produce in one laying from forty to fifty thousand. Mr. Lee describes one that he had under observation in an aquarium, which he says "would pass one of her arms beneath the hanging bunches of her eggs, and, dilating the membrane on each side of it into a boat-shaped hollow, would gather and hold them in, as in a trough or cradle. Then she would caress and gently rub them, occasionally turning toward them the mouth of her flexible exhalent and locomotor tube, which resembles the nozzle of a hose-pipe, and direct upon them a jet of water." The object of the syringing process was probably to free the eggs from parasites, or to prevent the growth of confervæ upon them. At the end of five weeks some of the eggs were taken from the nest for observation under the microscope, which showed that the young octopods were already alive and freely swimming within the shell; and most extraordinary was it to see that these immature creatures exhibited the characteristic changes of color at that early

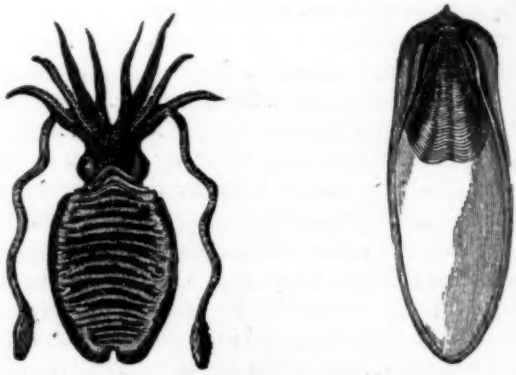

FIG. 8.—SEPIA OFFICINALIS AND SHELL.

stage of development, flushing red apparently with anger when disturbed. The period of incubation is about fifty days, and during all that time the mother octopus brooded her eggs with the tenderest care; so that the observer almost ceased to look upon her in the light of a "devil-fish," and recognized that at least the maternal instinct was not dependent for its development upon external beauty.

When the young octopus emerges from the egg it is about the size of a large flea, but has none of the arms developed; these appear simply as "rudimentary conical excrescences, having points of hair-like fineness arranged in the form of an eight-rayed coronet upon the head." The amiable disposition of all female devil-fish is not perhaps equal to that of the one described above; but it is not an unusual event for

them to die from the effects of exhaustion at the end of the long brooding period. This may perhaps partly result from insufficient nourishment, as they must evidently miss many chances of obtaining food, which others, unburdened with family cares, avail themselves of.

The nearest relations of the octopus are the cuttle-fish and squids. The former, *Sepia officinalis*, is best known as the animal which produces that fine black-coloring fluid known as sepia-ink, and for its useful *sepiostaire* or internal shell, which is usually hung in the cages of canary-birds.

Though the cuttle-fish resembles in its general structure its relative the octopus, it varies in several particulars. Instead of eight arms, it has ten, eight short and two long. Some persons have pronounced them "beautiful"—in which opinion we cannot coincide; but their manners are decidedly more genial than those of the octopus. Instead of lurking in semi-concealed caves or behind rocks, and springing upon the unwary like a tiger from its jungle, the cuttle-fish comes out to the light and gives his intended victim a fair chance, having more the habits of a bird of prey than its congener the devil-fish. It is, however, very voracious, and fishermen have often cause to regret its proximity to the fishing-grounds, as it will attack fish while entangled in the nets and drag them out or bite and mutilate them. When attacked, its best defense is the sepia-bag, from which it ejects the black fluid, thus discoloring the water and escaping in the obscurity.

The eggs of the cuttle-fish are usually found attached to a branch of sea-weed and very ingeniously hung by a perfect loop, each one separately upon the twig, where together they somewhat resemble a bunch of grapes. As soon as the young are released, they seek the light and approach the surface of the water. The sepia is naturally very shy, and at the slightest alarm shoots forth with wonderful rapidity its foe-defying ink; but in captivity its fears may be overcome by kindness. It is not difficult to tame, and in time it appears to recognize and appreciate its protector, ceasing to discolor the water when sufficient familiarity has been established between them.

The eyes of the cuttle are so solid as to be almost calcareous, and are divided by a groove in the centre; these halves are nearly globose at their outer surfaces, and reflect light with a "beautiful nacreous opalescence and play of colors." In Italy they are made into beads for necklaces. The cuttle-bone when pounded is used as a polishing powder by jewelers, under the name of "pounce." It is also manufactured into a dentifrice, and sold under the name of "white coral-powder." Artists still use the natural *sepia* to some extent.

The *common squid* (*Loligo vulgaris*) has the same number of arms as the cuttle, but differs in form and some other particulars. The body of the cuttle is of a broad oval shape, with no perceptible neck; the squid is nearly triangular in shape, and has two plainly defined necks, one much smaller inserted within the other and projecting beyond it.

It has also very large eyes in proportion to its size. It is a free swimmer like the cuttle; its spawn is also left to float freely, but in a large circular mass, consisting of an immense number of branches, all containing quantities of ova and united to a common centre. It has been estimated that these "mop-like" masses contain nearly forty thousand eggs. The squid is also privileged to carry an ink-bag, of which he makes very free use; and many fishermen attempting to catch them have experienced the fate of Tom Hood, of whom Mr. Lee tells the anecdote that, being unaware of this propensity of the cuttle-fish and squid, and having caught one of the former on his hook while angling in Love Harbor, he laid hold of it to unhook it, and received its full *jet d'eau* in the face. On being asked what he had on his line, he replied that he did not know exactly, but he thought *he had caught a young garden engine!*

As these sorts of creatures are never eaten in this country, it may be news to some that they are very extensively used as food in many countries at the present time, and that the ancient as well as the modern Greeks considered them a delicacy when properly cooked. One cause of the favor in which they are held by the Orthodox Greek Catholics on the shores of the Ægean Sea is the substitute which they offer in place of meat and fish, both of which are forbidden during the long fasts of the Greek Church. A cuttle is practically declared not to be a fish, and certainly it is not meat; and so it finds its way into the pots and frying-pans even of the ecclesiastics during Lent and other fasts in great quantities. A common way of catching them in the Mediterranean is by planting traps of stone jars or earthenware tubes, into which they creep, and are thus drawn up and secured. Everywhere they are used for bait, and the Indians of Vancouver's Island and Alaska eat them with relish, as do the inhabitants of China and the western coast of South America. There is a good story told of a party of *savants* in England endeavoring to make a dish of one, at a special dinner given for the purpose; but the attempt was a complete failure—no one could swallow a morsel. The ancients described them under the name of *polypus*, and all classical scholars will recall the frequent references to these animals as articles of diet, especially by the comic poets.

The greatest enemies to the class of cephalopods are the porpoises, dolphins, and conger-eels. The last do not hesitate to attack even a devil-fish of considerable size, while the young are snapped up by a great variety of fishes. In fact, if the great mass of all the spawn produced by the denizens of the ocean were not devoured or otherwise destroyed, the watery world would long ago have become so over-populated as to be unnavigable, and its condition incompatible with the health of the human race.

HEREDITY.

By GEORGE ILES.

HAWTHORNE in his masterpiece, the "Scarlet Letter," makes his heroine, Hester Prynne, a woman who has sinned, resolutely refuse to tell the name of her partner in guilt when the Puritan inquisitors urge her to do so. The ministers of justice and vengeance then turn to her child, and sharply scrutinize her features, to find if possible some trace of her father's look, that the wrong done may be punished. Here, too, they are unsuccessful—the face of the little elf tells no story that they can read, gives them no clew in their task of detection; they are obliged to withdraw, baffled and surly. This incident in the greatest of American romances is true to experience; while the inheritance from parents of form and character is general, yet it is not universal, and while some of the exceptions, when explained, afford very interesting studies of the play of natural forces, too subtile to be noticed by simple inspection of their results, yet many anomalies exist in heredity which the science of to-day is quite incompetent to explain.

The inheritance of the peculiarities of physical structure is a matter of daily and hourly observation, and the minute fidelity of it is at times very remarkable. Agassiz placed on record cases where traces of surgical operations had been transmitted. Sometimes parent and child are not only alike in form and feature, but even in tricks of tone and gesture, handwriting and gait.

The predisposition to certain diseases, like gout or insanity, often developed after maturity, is transmissible; and also the liability to die about a certain age. The famous Turgots, for more than a century, rarely exceeded fifty years of age; and insanity often appears after the meridian of life in several successive generations of a family. The remarkable faithfulness of reproduction in the majority of cases is a fact somewhat parallel to the growth and maintenance of an organism, wherein, with the constant succession of cells each of brief existence, substantial identity is kept up. There do not seem to be very marked differences in babes, yet from the same food one will become a man of muscle and energy, another of nerve and brain, a third a portly man of ease-loving habits. All the original peculiarities of each tiny human nucleus pick out from a common nourishment elements like themselves, rejecting the rest.

Inheritance is not only physical, but intellectual as well; great ability in mathematics, painting, music, and other departments of effort, has clearly been received at birth in many thousands of examples. The Bach family for two hundred years maintained exalted rank in music. The direct succession of very able men in the families of

Pitt, Napier, Fox, Herschel, Darwin, and many more, is evidence that mind and will are as transmissible as complexion and stature. This is more apparent in a country like England, where the institutions and customs favor and confirm the results of heredity, than in America, where there is no law of entail, and as yet little of the ambitious founding of families.

There is abundant testimony to prove that heredity can be moral as well as physical and intellectual. The Stuarts were as constant in the presentation of certain moral traits as the family of the Churchills or the American Adamses are in others. Imprudence, penuriousness, dishonesty, or good judgment, once thoroughly established in a stock, persists with quite as much tenacity as the familiar eyes or nose. The inheritance by posterity of the changes wrought on individuals by their experience is the basis of the modern explanation of the growth of instinct and the evolution of human intelligence. Darwin has developed this theory in a masterly manner. He gives as an illustration that between the finished skill of the honey-bee and the rude capabilities of the humble-bee stand the intermediate powers of the Mexican melipona. This last insect constructs a comb of wax, almost regular in form, consisting of cylindrical cells, in which the larvæ are hatched, and a certain number of large cells to hold its store of honey. The latter cells are nearly spherical and situated at a considerable distance from each other. Now, any slight variation of organization or instinct, by which the melipona would construct its cells more uniformly and compactly, would economize its wax and labor, and bring it up toward the plane of the honey-bee. The generations of insects succeed each other so rapidly that no modification can be detected among species low in the scale. Honey-bees, however, are not possessed of unadaptable and rigid instincts, for they have been observed to spring arches and buttresses in their hives to avoid glass rods purposely inserted. An organism's advantage plainly lies in an increase of its skill and ingenuity, and any slight advance made by individuals is preserved by heredity, persists in tendencies and habit, and becomes fixed as instinct.

The development of intelligence among mankind is accounted for in the same manner: efforts at first painfully made by our ancestors in new paths were at last rewarded by the facility that comes with repetition; their immediate descendants were born with new aptitudes and an organization with a wider range of powers; the acquisitions thus gained and transmitted have grown into the varied faculties of the men and women of to-day. "Mankind," Comte says, "is as one man, always living and always learning." The passing away of one generation and the birth of another do not interfere with the constant progress of the race.

The method applied to the explication of the growth of instinct and intelligence has been used by Darwin in approaching the problem

of the origin of the conscience from the side of natural history. He deems it to have had its beginning when an animal could contrast the transient pleasure given by the gratification of a passion with the abiding pain afterward felt. An enlargement of memory must have come before the immediate and remote effects of actions could be compared in consciousness, and the greater good recognized and chosen.

This theory of conscience, which holds it to have been created by the experiences of the race confirming habits best suited for social life, well accords with the theory of morals which takes benefit or utility, in its largest sense, as the test and sanction of right conduct.

While the manifestations of heredity in their obvious effects are interesting, yet the laws brought to light by an examination of some results apparently exceptional and contradictory are of still deeper interest. A single great law may underlie a large group of problems, yet many other principles of minor weight may coöperate with it and obscure its direct force. The study of residual phenomena is ever fraught with increased knowledge and the unfailing testimony that where law seems to be at fault it is only so from our ignorance of the varied energies at work, which are constantly revealed to the patient searcher for truth. In the science of heredity many apparent anomalies have been resolved in allowing for the action of forces newly discovered or applied.

The study of the unconscious powers of the mind has of late years attracted much attention; observation has found that there may lie latent in a man tendencies and forces whose existence he may never suspect, but which he is capable of transmitting to children who shall palpably develop them. Insanity, gout, and melancholia, frequently skip a generation and reappear when hopes have been entertained that the evil trait had died out in the family. A son may resemble his mother very markedly, and have children with the features and character of his father. The evidence of heredity is thus borne out frequently in the long-run, when to a contracted view it would seem at fault. An individual inherits not only from his parents but from all their predecessors in the line of life, and just what of them shall appear evidently in him, and what be hidden in unconsciousness, none can tell. The surface forces of the man may be like the momentum of a tree falling down a mountain-slope, but the inner and dormant powers never to be manifested during a lifetime may as far transcend the energies actually shown as the force of the fire which the tree may feed excels that of its mere bodily impact in descent.

The dormancy of traits accounts for atavism or the reversion of an organism to the form and character of ancestral stock. Pigeons, dogs, and horses, frequently relapse, so to speak, to the inferior type from which they have been bred, and so exhibit a wide divergence from their immediate parents. Reversion of this kind has been noticed in the silkworm after a hundred generations. So long in Nature does an

organism retain substantially the same form, that when art produces a rapid modification of structure, or desires to seize upon a valuable and marked variety, repeated and careful selection is required to give it permanence.

The principle of atavism explains the curious resemblance often seen in a human family between uncle and nephew; the likeness in such cases is derived from some common ancestor, the grandfather most usually.

Mr. Galton, in his work on "Hereditary Genius," adopts the statistical method to prove that illustrious men arise oftenest from families displaying eminent talent, and have relatives approaching to themselves in ability in a degree proportioned to the nearness of kinship. A man of genius is much more likely to have a remarkable father or son, than a nephew or cousin. Great men, Galton says, seem to arise like islands, isolated and unaccountable; but this is an illusion—they are given to us usually by parents unknown from the necessarily narrow limitations of fame; islands are but the tops of hills whose whole extent is hidden by obscuring ocean. Yet the exceptions to this rule are very numerous: why should Cromwell, Milton, Goethe, and so many others, leave behind them unworthy children? Was it from unfortunate mating with an inferior mother, or because the vitality, physical and mental, was too much drawn upon by the individual life for worthy continuation? How can it be explained that men like Burns and Faraday should come up from families in which even enthusiastic biographers can find nothing to distinguish them from their neighbors?

The wide unlikeness frequently observed between parents and children in talent and character suggests an analogy with a familiar fact in chemistry. A compound's color, weight, and other properties, may be changed almost beyond recognition by adding or eliminating a single element. It is somewhat so in human nature; a father of warm passions or strong acquisitive impulses may transmit all his traits to a son, except prudence; and the omission may cause much sympathy for a reputable and worthy man's being afflicted with a boy so unlike himself. If the lack in inheritance be in perseverance and application, of what value are splendid talents without them?

A lens externally not to be distinguished from a perfect one may, from some slight defect in composition or handling, give images blurred and distorted, instead of true and beautiful. A chain is no stronger than its weakest link, and a small lack or discordance in the elements of character may exclude it from the exacting demands of high place. We often hear regrets that men of genius so rarely have living descendants, but we must not overrate the persistence of ordinary families: taking the first eleven names of acquaintances that occurred to me, I found that three of them were in a fair way of being the last of their race; every old person can recollect the dying out of many once numerous families.

Ribot, the French authority on heredity, alleges two causes as among the chief at work in cases where the law of transmission does not obviously manifest itself. The first is the disproportion of an initiatory force to the amount of energy it may liberate or direct, as in the slight agencies by which fires are lit or explosions set off. The accidental surroundings of a mother before the birth of her child may affect it for life in a way altogether disproportioned to the forces at work. The military excitements in which Madame Bonaparte lived just prior to Napoleon's birth are well known. Anxiety, grief, elation, an unusual degree of physical health or debility at such times are productive of very striking effects, quite capable of masking the likeness between parent and child in form and disposition. The Greeks believed so strongly in the potency of prenatal conditions that they not only guarded mothers who were bearing with the kindest care, but used even to surround them with beautiful works of art, that imagination might act a favorable part.

The second cause which Ribot thinks often tends to obscure the evidence of heredity is the transformation in development of characteristics which are the same at root. Thus a consumptive father has a son who suffers from rheumatism or paralysis. Here the transmission has simply been that of a feeble constitution, which gives way in the first circumstances of severe trial—those favoring rheumatism, paralysis, or other disease. The crystal of life, to use Galton's figure, is disturbed, and reposes on a new facet. In cases where talent appears conspicuously in a family, it may be that energy and patience, productive of but ordinary results in a father, are directed by his son to supplying some new public want, or filling a position created by some sudden national emergency. The constructive powers of Stephenson were less remarkable than his dogged perseverance; and when the world needed steam locomotion he was the man to give it, and surmount the immense difficulties in the way. His strong will is not a rare trait of character, but, joined to his ingenuity, it won him success in his great opportunity. Had Charles I. been a good king, Cromwell would probably have died a brewer. Unbending will was also his chief characteristic, but at Huntingdon it could have enjoyed but narrow play.

Readers of the MONTHLY may remember Galton's paper on "Twins," published in January, 1876. In that paper, based on wide and carefully-made comparisons, it was proved that in the production of character original constitution is a much more important factor than either education or surroundings. The resemblance of twins when it occurs, as it frequently does very strongly, continues through life in a large proportion of cases. The same author has confirmed his opinion that Nature is more powerful than nurture in moulding men, by collecting elaborate testimony from all the illustrious Englishmen of science now living, who say for the most part that their tastes were either innate or manifested themselves very early under the influence of training, and in

some few cases were developed in antagonism to a particular kind of education imparted to them.

Galton thinks that the natural differences among men are far wider than commonly supposed: from a careful study of the statistics of Cambridge examinations, he estimates that the capacity in mathematics of a senior wrangler is to the lowest in the scale of students taking honors as three hundred to one. Similar results have been arrived at by comparisons made in other branches of learning. From all this, it would seem that the popular mind not only underrates the natural differences of men, but also exaggerates the real limits of the improvability of the masses of mankind. Education can only call out one's powers, not bestow them where they are lacking; and supreme minds almost seem to be independent of education, or, at least, always able to get all they need. The task of diffusing information is comparatively an easy one, but the absorption and vitalization of it in the receiving minds is a matter quite beyond the teacher's skill. While we should not expect too much from instruction, we may rightly expect a great deal if it be wisely given; and here it may be fitting to draw attention to a danger in our modern schemes of education, very ably pointed out by Johnson in his recent work on China. The increasing uniformity in methods of instruction, while it may tend to the adoption of the one best plan for an average scholar, has a disadvantage in repressing individuality, and abolishing the many special kinds of teaching for which some teachers are peculiarly fit, and by which some of the best kinds of scholars, different from the average, are notably benefited. The narrow line of a great circle is undoubtedly the shortest path for a ship to take, but, if we would explore new seas and find new truths, the sharply-defined curve of economic navigation must be departed from; and the more diverse the tracks of the ship-master, the more of the deep waters of the unknown will he map out for us.

Instructors sometimes err in being too early in their work, as well as too uniform in their methods; so that matters of great moment lose the bloom of novelty before the reason needed to grasp them matures. One of the compensations for an education coming late in life by one's own effort or otherwise is, that the wonderfulness and suggestiveness of truths come to the mind undampened by any early and useless familiarity.

In the cause of education it is to be regretted that men of the greatest natural endowments can so rarely describe their processes of thought, or analyze their methods of arriving at results. The intuitive perceptions derived from inheritance or long personal experience are of coalescent quality, and are of too rapid awakening to be capable of explanation and record in consciousness. The most original thinkers are, therefore, seldom gifted with the teaching-talent; just as orators and statesmen are not often eminent as authorities in elocution or political economy. Few of the ways and means of intellectual acumen can

be reduced to rule and definitely expressed, yet the error is perennial of regarding logic as reason, and calculations, necessarily imperfect from the extent and complexity of the forces at work, as sound judgment.

The modern view that human intelligence is due to the experiences of the race organized in the brain gives an explanation to a very interesting group of facts. When the education of an individual is totally unlike that received by his line of progenitors, it cannot take deep root in his nature. Every conscientious Christian missionary laments the difficulty of making a really deep impression on a pagan mind. The momentum of ages cannot be changed in direction in a single life, and, if it could, the pledges of human progress, which after all are based on human permanence, would be done away. In the conflict between inherited instincts and personally-acquired convictions, it is as if the man were attempting to fight all his ancestry at once, and he is usually worsted in the fray. Natural historians are familiar with the survival in animals of habits once useful to them in the distant past, but in their changed conditions no longer so. Some reptiles now living on land possess the remnants of organs once used in their perfection by their remote ancestry in aquatic life. In a somewhat parallel way, the superstitions of our progenitors persist in many persons of undoubted common-sense. Madame de Staël said, when asked if she believed in ghosts, "No, but I am afraid of them." When we consider the great problems of life and death in hours of calm reason, our reflections are apt to take a direction very different from that along which our instinctive feelings may impel us in seasons of pain and distress. It is a poor apology for a crude theological belief that our instincts declare it to be true, however much reason may contradict it. Instinct has no infallibility: in the human mind it is simply the register of thoughts and experiences during the long, primitive ages of our race; and our own opinions formed by personal accumulation since birth more probably point toward truth, than the lines of feeling laid down in our fibres in times of struggling intelligence and fierce strifes with natural powers, awful and unknown. In the conflict between instinct and reason, it would be strange indeed to contemn that reason which is only a better instinct than we have now, in the making. The study of race-impulses in an individual makes clear why it is that a man will do generous, heroic deeds, from which it is impossible for him to derive advantage. He acts as he does not from calculation, but from instinctive incitements inherited from parentage of noble blood; the line of race-benefit may not always coincide with that of individual good, but the impetus of ancestral forces transcends self-regard, and leaves the account of debit and credit apparently unbalanced. Not only are human instincts at times noble and heroic, but also, unfortunately more often, cruel and destructive. When a war breaks out, or any great public dissension arises, how speedily can the thin plating of civilization be abraded

away, exposing the old barbarism of the under-nature! The sanguinary and destructive instincts of a people, once thoroughly let loose, can overturn in a few days a social fabric painfully wrought by generations. Of popular outbreaks of fury history has many terrible records, and none more so than of those revolts against order which, as in the French Revolution, had a core of justice in them. The natural differences among men in ability are very marked; much less so are their different capabilities of enjoying the rewards of skill and power: hence inevitably arise discontent and the ignoble spirit of envy; any artificial increase of the gulfs drawn by Nature between one man and another excites this discontent and envy by a conviction of injustice, and endangers order. From these causes the artificial enrichment of nobles and clergy by exemption from taxation has again and again deluged Europe with blood; and the enormous accumulations of property in private hands by bequest and increment have even in America excited concern. In considering this subject, Mill proposed that there should be a moderate limit to the amount one might legally receive by gifts and bequests; and the same thinker, and others of equal eminence, have declared their conviction that land shall at some future time, near or remote, be redistributed on some equitable plan.

The law of heredity has an important bearing, not only on questions of education and property, but also on the problem as to the best treatment of the criminal classes. Since the human character is so much dependent on inheritance, and so indelibly impressed by depraved associations in early life, it is thought that all incorrigible offenders, as soon as their state can be proved, should in some right way, by imprisonment or otherwise, be prevented from propagating their kind. Dr. Dugdale, of New York, followed the lines of descent from one Margaret Jukes, through six generations, including in all seven hundred and nine persons — thieves, prostitutes, murderers, and idiots. The Chinese so firmly believe depravity to be a taint of blood, that a criminal's father and grandfather are sometimes required to perish with him; conversely, this nation of ancestor-worshipers deem a man so much indebted to his parents for all that makes him great, that when a citizen is ennobled for eminent services, titles are bestowed upon the ascending line of the family, and not the descending, as with us.

Important as the relations of the law of heredity may be in the various topics adverted to in this paper, none can be so much so as the comprehension of the law, and obedience to it in marriage. The lower animals are carefully bred, while men and women mate with rarely any rational reflection as to their fitness for each other, thus often entailing upon themselves and their offspring woes unspeakable. The plain sense which should forbid the consumptive, syphilitic, or scrofulous, from marrying is disregarded, and the results are terrible. When one's constitution is impaired by some not serious organic ailment, special pains should be taken to avoid the like in selecting a partner for life. Physi-

ologists deem consanguineous unions to result as badly as they often do from the parents inheriting from their one common stock similar weaknesses which unite in their children to form a lower deep of organic deficiency. With very good constitutions, men have been known to marry their sisters with impunity, as some of the Ptolemies did; but, when the stock of the Egyptian monarchs declined in soundness, their close intermarriages resulted in a rapid and frightful degeneracy.

Where there is no blood relationship between parents, they sometimes produce booby children, from having a too close temperamental similarity. The most trustworthy authorities on this subject say that in marriage a moderate difference between the constitutions and characters of the parties, and complementary rather than antagonistic, is best. A noteworthy consideration in selecting a wife is, that as a mother has much more influence on a child's character than a father, if she has any marked bad trait, as a violent temper, laziness, or vanity, and if that trait be transmitted to her offspring, then the child will be brought up by a woman the least fit of her sex to recognize the child's faults, and eradicate them as far as possible by proper training. In the rearing of young children, close associations have great influence. A professor of McGill University assures me that the infants of his family acquire a resemblance to their nurse in expression, which only disappears when they are removed from her.

A happy and hopeful marriage may be marred in its results from procreation taking place while sickness, anxiety, or grief, has lowered vitality; and the too frequent bearing of children is very seriously detrimental to both mother and progeny.

When a parent transmits a malady, carefulness in living can frequently prevent its development; but when disease or predisposition to it is acquired from a parent together with the carelessness or self-indulgence of character which originally induced the disease, then the taint of blood is confirmed and increased. Many persons of weak frame prolong life to old age by prudence and abstemiousness, whereas the conscious possession of a vigorous constitution is a constant temptation to abuses of it. Length of days depends less upon the quantity of vital energy received at birth, than on the jealous care of health and strength.

In these matters, as in all others, we not only need to know much, but to know it so long that we shall act upon our knowledge. The discrepancy between the intellectual acceptance of truth and moral obedience to it is wide as the gap between Ideal and Real.

THE PHYSICAL FUNCTIONS OF LEAVES.

AN elaborate study on the above subject has lately been published by Prof. J. Boussingault, of Paris, in the "Annales de Chimie et de Physique" (vol. xiii., pp. 289–394), in which the phenomena of absorption and transpiration by leaves are treated at great length. Since the memorable experiments of Hales in 1727, recounted in his work on "Vegetable Statics," this branch of vegetable physiology has been rarely touched, and the carefully recorded observations of Boussingault, carried out with the best of modern scientific appliances, possess an unusual value.

The first point studied was the loss of water by transpiration from the leaves of plants under normal circumstances. For this purpose a healthy Jerusalem artichoke (*Helianthus tuberosus*) in a roomy flower-pot was chosen. The top of the pot was covered with a sheet of India-rubber, tightly inclosing the stem of the plant, and provided with an opening for the admission of water. The whole was then weighed, and the loss noted which ensued under various circumstances, by evaporation of water from the leaves, the plant receiving during the experiment weighed normal amounts of water. The total surface of the leaves of the plant (both upper and lower sides) was carefully estimated, and the result reckoned on the square metre. The averages of fourteen experiments showed that the artichoke lost hourly, for every square metre of foliage, the following amounts of water: in the sunshine sixty-five grammes, in the shade eight grammes, during the night three grammes.

In the next place the question was investigated whether the absorption of water by plants and the ascent of the sap are due to the force resulting from the transpiration on the surface of the leaves, or whether the roots exercise also a certain amount of force to this end. For this purpose experiments similar to the above were carried out with various plants, firstly under normal circumstances, secondly with the stem minus the roots immersed in water. As an instance we can take mint. The plant with roots showed an hourly evaporation per metre of eighty-two grammes in the sunshine and thirty-six in the shade. Under the same condition without roots, the evaporation was sixteen and fifteen grammes respectively.

The results show that the absorption of water by plants is determined in a great measure by the transpiration occurring in the leaves, that this is maintained for a certain length of time without the assistance of the roots, but cannot continue long, being dependent on the injective power possessed by the roots. The effect of pressure on the absorption was next examined, and it was found possible by this means for a time in certain cases to even more than replace the water lost by transpiration. For example: a chestnut-branch dipped in water was

found to transpire hourly per metre of foliage sixteen grammes. It was then inserted into a tube of water, and subjected to the pressure of a column of water two and a half metres high. Under these conditions the evaporation mounted to fifty-five grammes per hour, and the branch at the end of five hours weighed more than at the commencement.

The general result of these experiments shows the mutual working of the various parts of the plant with reference to the phenomena of transpiration. The roots, absorbing water from the soil by endosmose, direct it toward the stem. Whether the motive force here is injection by the roots or absorption resulting from the transpiration in the green parts of the plant, or a union of both, is a question still unsettled. The

FIG. 1.

FIG. 2.

stem serves not only as a passage for the water to reach the leaves, but also as a reservoir to be drawn on during rapid evaporation. In the leaves the sap is concentrated by the transpiration, and the matters in solution enter into the cell formation, or, changed by the action of light, are distributed throughout the plant by the descending sap. The circulation would be quite similar to that in an animal, were it not for the irregularity. While the supply of water from the roots varies but slightly, the loss by evaporation from the leaves is subject to the greatest fluctuations, according to the temperature and hygroscopic condition of the surrounding air. During these periods the leaves draw on their stock of constitution water and the supply in the stem; and when both fail, the phenomenon of wilting ensues.

Numerous experiments were made on the difference in *evaporation during the day and during the night.* Those carried out with leaves of the grapevine gave the following hourly averages per square metre of foliage: in sunshine, thirty-five grammes; in shade, eleven; during the night, 0.5. The trellis on which the vine was trained was one metre high and thirty-eight metres long, and presented a surface of one hundred and thirty-eight square metres of foliage. In sunny weather this would lose by evaporation, in the course of twenty-four hours, forty-eight kilogrammes of water, and nearly half of that amount during cloudy weather. To give an idea of the enormous amount of aqueous vapor dissipated by plants in the sunshine, calculation showed that an acre of beets could lose in the course of twenty-four hours between 8,000 and 9,000 kilogrammes. Another experiment made with a chestnut-tree thirty-five years old showed that it lost over sixty litres of water in the course of twenty-four hours. The structure of the leaf, however, containing seventy to eighty per cent. of water, and possessing a thickness frequently of but one-tenth of a millimetre, would suggest the question why the evaporation is not much more rapid. The answer to this is found in the peculiar structure of the tissue forming the epidermis, designed especially to moderate the transpiration. In order to see the remarkable retentive power exercised by this epidermis, one can expose for a few hours to the sun two cactus-leaves of the same superficies, one of which has been deprived of its epidermis. The evaporation in the latter case will be about fifteen times as rapid as in the other. It is the presence of a similar tissue forming the skin of fruits which prevents an otherwise rapid evaporation. For instance, an apple deprived of its skin loses fifty-five times as much water as a whole specimen in the same time. Losses by rapid evaporation lessen notably the physiological energy of leaves. Thus an oleander-leaf containing sixty per cent. of water, when introduced into an atmosphere containing carbonic acid, decomposed sixteen centimetres of this gas; one containing thirty-six per cent. decomposed eleven centimetres; and one containing but twenty-nine per cent. was without action.

A series of observations was made on the relative powers of *evaporation on the upper and lower sides of leaves.* They consisted in plucking two leaves of the same kind at the same moment, covering on the one the upper, on the other the lower side with melted tallow, and then noticing the loss of weight by evaporation in a given time. The average of the results showed that the proportion between the amounts of water evaporated on the upper and lower side of a dozen varieties of leaves was 1: 4.3. In all cases the amount evaporated from the two exposed sides of two equal leaves was greater than from the entire surface of a similar leaf under the same circumstances.

A point of no small interest with regard to the physical function of leaves is that of their ability to replace the roots of a plant in serving as the agent of absorption. A variety of tests were undertaken to set-

tle this question; among them the following: A forked branch of lilac (Fig. 1) was so disposed that the one branch was immersed in water, while the other was exposed to the ordinary atmospheric conditions. The superficies of foliage was the same on both branches. The transpiration from the surface of the leaves on the latter branch was the same as under normal circumstances, and after the lapse of two weeks the foliage was as fresh as at the commencement, showing that the submerged leaves were fully able to replace the roots in one of their functions. In an experiment with a beet in which one-half of the leaves were in water and one-half in the air, communication being maintained by means of the root, the free portion of the leaves wilted in the course of a day, the neck of the root apparently not offering a sufficient means of communication with the submerged leaves A grapevine shoot half plunged in water (Fig. 2) maintained a normal evaporation in the free foliage, and remained fresh for over a month. An oleander shoot under similar conditions maintained its normal appearance for four months. With the artichoke it was found necessary that the surface of the leaves beneath the water should be four times that of the leaves above.

Closely bordering on this question is another which has excited much dispute, viz., the ability of leaves to draw water from the surrounding air or by immersion, after having suffered losses by transpiration. Prof. Boussingault's numerous experiments show that leaves, after having been exposed to influences causing a rapid evaporation, are able to absorb water rapidly on immersion, and even from an atmosphere saturated with aqueous vapor. There is, however, in both cases no absorption unless the leaves have lost a portion of their water of constitution, i. e., that which is essential to their normal existence. Thus, a wilted branch of periwinkle weighing 4 grammes, after remaining in an atmosphere saturated with aqueous vapor for a day and a half, weighed 4·2 grammes, and after twelve hours' immersion in water 9·4 grammes.

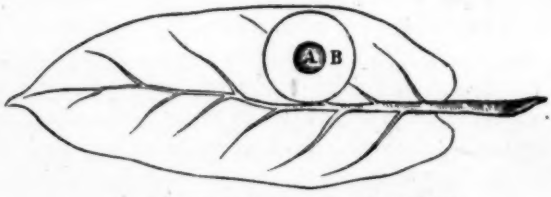

FIG. 3.—*A*, drop of solution; *B*, watch-glass.

The last function of leaves studied by Prof. Boussingault is their ability to absorb solutions of mineral matter, i. e., perform another of the ordinary duties of the roots. For this purpose a solution of gypsum containing $\frac{2}{1000}$ of solid matter was used. Drops of this solution were placed on the leaves of a great variety of plants—under conditions favoring absorption, as in the experiments just described—and protected

from evaporation by superincumbent watch-glasses with greased edges (Fig. 3).

In most instances the drops were absorbed entirely, leaving no traces of the mineral matter; in some cases a slight residue was left, which the addition of a minute quantity of water caused to disappear. As in the case of pure water, the under side of the leaves absorbed much more rapidly than the upper side. Solutions of sulphate and nitrate of potassium gave quite similar results; the absorption of solutions of chloride of sodium and nitrate of ammonium was not so perfect. These results would tend to show that the foliage of a plant is able to supply it with perhaps no small portion of its saline constituents by means of the ammoniacal salts formed in the air, and the alkaline and earthy salts suspended there which are deposited on the surface of the leaves by rain and dew.—*Nature.*

CURARI OR WOORARA POISON.[1]

By MAURICE GIRARD.

IT is almost three centuries since Sir Walter Raleigh, after the discovery of Guiana, brought to Europe some arrows poisoned with a substance called by him *curari.* This poison was then in general use among the tribes inhabiting the Atlantic slope of South America. To-day we must penetrate into the depths of the forests to find the remnants of the ancient populations who possess the recipe for preparing curari. It may safely be affirmed that by next century it will have disappeared, either through the annihilation of these races, who are vanishing before the whites, or blending with them by intermarriage, or, above all, because firearms, obtained by way of barter from European traders, are steadily superseding the ancient implements of war and of the chase.

The arrow-poison is usually prepared from a substance often called *veneno* by the Spanish-Americans, and which occasionally happens to be brought to Europe under the name of *curari.* This substance, which the natives carry about in little earthenware pots or in calabashes, is a black, solid extract, with glistening fracture, in appearance very much like the black, inspissated juice of licorice. The active principle of curari is soluble in water, alcohol, blood, and all animal fluids; it is mixed with many impurities, which remain suspended in the solution, and among which the microscope detects vegetable *débris,* cells, and fibres. Ether and spirits of turpentine precipitate the curari poison, and in this way Messrs. Boussingault and Roulin have been able to isolate the active principle of curari, which they call *cu-*

[1] Translated from *La Nature* by J. Fitzgerald, A. M.

rarin. Its chemical constitution is not yet made out; it is not crystallizable, has the look of horn, is very hygroscopic, and easily soluble in water and in alcohol. The watery solution is not affected by boiling, and appears to preserve its toxic property for an indefinite time, precisely like the dried curari on the tips of arrows, a circumstance which renders these weapons very dangerous objects to handle.

Curari is prepared at long intervals by the natives of South America, whenever the supply, which is divided between the hunters and the warriors, has become exhausted. The mode of preparation differs according to locality, but these differences are not essential. The ingredients are everywhere either the same or at least analogous, for the curaris manufactured in different regions amid the almost unexplored forests of Guiana and Brazil always present the same toxic properties. Sometimes curari is prepared openly and without mystery on some high festival of the tribe, with the usual accompaniment of copious libations of strong drink. And, by-the-way, it has been remarked by Humboldt that during a festival it is a rare thing to find a native that is not intoxicated, drunkenness being unfortunately, in all latitudes, the habitual expression of gladness among the ruder classes of mankind.

At other times the arrow-poison is prepared only by the medicine-men, who hedge its preparation around with superstitious practices and mystic ceremonies, designed to enhance their own prestige and influence. The exaggerated reports of travelers have still further complicated the matter, as when we are assured that in the preparation of the curari some old hag of the tribe shuts herself up in a hut with the kettle in which the poisonous ingredients are boiled, and that, if the process is successful, she herself dies by inhaling their noxious emanations. This is a fable, for curari is not volatile.

It has also been stated that, when the curari begins to thicken, the natives throw into the pot ants with venomous stings, and the fangs and poison-glands of the most deadly serpents, such as the rattlesnake. Possibly these accessories may have sometimes been employed, but we now know that they are not essential, and that excellent curaris are prepared solely from vegetal substances. According to Goudot, the tribes living on the New Granada frontier cut down in the woods certain climbing plants of the genus *Strychnos*, from which exudes at the cuts a quantity of acrid sap. The wood is crushed and macerated in water for forty-eight hours; it is then pressed, and the liquid is carefully filtered. After filtration it is slowly evaporated, till it reaches the required degree of concentration. It is now distributed among a number of little earthenware pots, which are placed on hot embers, and the process of evaporation is carried on with still greater care, till the poison acquires the consistence of a soft paste and is perfectly free from water.

Dr. Jobert is now engaged in studying in their native habitat the properties of the various plants which are known to have been em-

ployed in the preparation of curari, and he has had prepared under his own supervision, entirely from vegetal substances, one of the best of American curaris, that of the Tecuna Indians living on the Calderão, Brazil, near the Peruvian border. Some fine scrapings of *Urari uva*, a climbing plant of the genus *Strychnos*, and of the *Eko* or *Pani*, of the family *Menispermaceæ*, also a climber, were steeped in cold water. This liquid was then boiled for six hours, and there were thrown into it fragments of various plants, among them an *Aroidea* (*Taja*), and three different species of *Piperaceæ*. In this way the liquid was made to assume the consistency of mucilage; it was then suffered to cool, and became as thick as shoe-blacking. Dr. Jobert has found by experiment that the *Urari* and the *Taja* are the most rapidly fatal in their effects of all the ingredients, and that the *Pani*, administered by itself, is less rapid.

The Indians use curari to poison their arrows both for hunting and for war. The hunting-arrows, intended to be shot from a bow, have a detachable point; those shot from the *sarbacand* or blow-gun are very small, and consist of a slender shaft of iron-wood with a very sharp point, which bears the poison. Sometimes the poison is used highly diluted or in very small quantity, so as to produce in the victim simply a numbness, which passes away by degrees, but which in the mean time checks the animal in its course or in its flight, or causes it to fall from the tree in which it may happen to be. It is thus, we are told, that the Indians capture monkeys and parrots for sale to the European traders. Often the animal is killed by the arrow, but nevertheless its flesh may be eaten with impunity, for the very minute dose of the curari which enters the stomach with a mass of food is innocuous. Indeed, we know that curari, like the venom of serpents and the saliva of a rabid dog, may be introduced without injury into the digestive organs, provided the mucous surfaces of the latter are free from all lesion.

Curari has been mixed with the food given to dogs and rabbits in quantity far more than enough to produce fatal poisoning through a wound, and yet the animals have suffered no inconvenience.

Claude Bernard, however, has very clearly shown that this innocuousness of curari when administered through the stomach is relative only. In this respect curari resembles many other substances, both medicines and poisons. The peculiarity of their action is explained by the property which amorphous substances possess of being very slowly absorbed by the mucous membranes. By young mammals and birds while fasting, and while intestinal absorption is very active, curari cannot be taken into the stomach with impunity. We can only say that it takes a much larger quantity of curari to produce poisoning through the digestive organs than through an external wound.

Curari introduced into living tissues produces death all the sooner the more quickly it enters the circulation. Death comes quicker when

a solution of curari is injected under the skin than when the dry poison is introduced by the point of an arrow. Vigorous animals with rapid circulation of blood are more easily poisoned than those which are weakly; and with an equal dose of poison and with animals of equal size, those whose temperature is constant die more quickly than those whose temperature is variable (reptiles, batrachians, fishes), and, among the former, birds succumb more quickly than mammals.

The animal at first does not feel the wound, for curari possesses no caustic property. In the case of very small animals death is almost instantaneous. In birds and mammals of a large size, and in all animals of variable temperature, death usually occurs in from five to twelve minutes, if there is an excess of the poison. The animal lies down as though it would sleep, keeping the eyes open, with a placid expression. Soon it is seized with a progressive paralysis of the motor nerves, proceeding from the extremities to the centre. The muscles of respiratory movement are the last to succumb, and the animal dies from asphyxia.

To all appearance, nothing could be calmer than this progressive state of stupor; there is no agitation, no expression of suffering. The mouth remains shut, without foam or saliva. Life seems to be extinguished slowly, like some liquid that gradually flows away. In view of these treacherous symptoms, a member of the Society for the Prevention of Cruelty to Animals might be tempted to urge the use of curari in lieu of the brutal modes at present in vogue for slaughtering old, worn-out horses.

To Claude Bernard science is indebted for the exact determination of the specific action of curari. Vital activity presents a threefold series of distinct and coördinated organic elements, which play the part of excitants of one another. The starting-point of physiological action is the sensitive nerve-element. Its vibration is transmitted along its axis, and on reaching the nerve-cell—a regular relay—the sensory vibration is transformed into a motor vibration. This latter, in turn, is propagated through the motor nerve-element, and on reaching its peripheric extremity causes the fibre of the muscle to vibrate, and this, reacting in virtue of its essential property, produces contraction, and consequently motion.

Now, each of the three elements, sensory, motor, and muscular, lives and dies after a fashion of its own, and there are poisons proper to each. But, inasmuch as vital manifestations require the coöperation of these three activities, if one be suppressed, the other two continue to live indeed, but they no longer mean anything, just as a phrase loses its meaning if one of its members be dropped out. Claude Bernard's experiments have proved that the motor nerve-element alone is affected by curari, and that the other two organic elements of the animal retain their physiological properties. The mind is not destroyed, the muscular fibre still has the power of contraction, and indeed does contract under the influence of electric discharges. Motor power alone is de-

stroyed; if the characteristic manifestations of life have disappeared, it is not because they are really extinguished, but because they have been one after another turned back by the paralyzing action of the poison. In that motionless body, back of that lack-lustre eye, with all these semblances of death, sensibility and mind still persist intact; what looks to be a dead carcass hears and knows all that goes on around it; it feels pain when its body is pinched or burned; it still has feeling and will, but it has lost the instrument needed for manifesting them. The movements which are most expressive are the earliest to disappear—first voice, then the movements of the limbs, those of the face and the thorax, and lastly the movements of the eyes.

Is it possible to conceive a more dreadful torture than that endured by a mind which thus witnesses the privation of its organs one after another, and shut up, as it were, in the fullness of life within a corpse?

MOLECULAR DYNAMICS.

By L. R. CURTISS.

DYNAMICS refers to force or power. It deals with the primary conceptions of energy in its relations to subjects that are susceptible of numerical estimation, such as time, space, and velocity. Or, again, dynamics is that branch of science which measures the energies producing motion as well as those produced *by* motion, and is divided into two parts—kinematics, which pertains to motion without regard to the bodies acted upon; and kinetics, which refers to the cause of energies whereby motion is given to bodies, each of which is the antithesis of static energy or energy at rest. Molecular dynamics has for its domain the actual working forces inherent in the atoms and molecules of matter. This branch of the subject bears the same relation to physics as the differential calculus does to mathematics, and by thus dealing with the physical molecules and atoms we are enabled to extend the kinetic chain of causation down toward the infinitely small with a certainty almost parallel to the accuracy with which the integral calculus defines the motion of the planets.

The text-books teach us that one of the properties of matter is inertia, including both that of rest and that of motion, the former being defined as the passive condition of bodies when at rest. This definition refers to matter as a mass. The new philosophy, however, teaches that, since molecular motion refers to the invisible movements of the particles of the mass, there is no such thing as complete rest of the ultimate particles of matter short of absolute zero of temperature, which, if universal, means total frigidity of every sun and orb in the universe.

The current of scientific thought tends to demonstrate that all the

phenomena of Nature are to be regarded merely as varieties of motion, one guiding principle of which is conservation of energy. This being an established fact in science, it fortifies us in our position of reasoning downward in the direction of primary causes. By conservation of energy we are to understand that, while matter exists throughout the universe in definite quantity, there is also existing, as an attribute of matter, a definite amount of energy or force; and just so sure as matter is indestructible and *un*changeable, just so sure is force or energy indestructible and *inter*changeable. That is, matter and force are both indestructible, but force or energy (synonymous terms) is convertible into the several modes of force. The attributes of matter are attraction of gravitation, attraction of cohesion, and chemical affinity. Attraction of gravitation is a force exerted upon each and every atom of matter throughout the universe, with a never-ending geometric ratio, varying directly as the mass and inversely as the square of the distance. The force known as chemical affinity binds the integral particles of compounds in an embrace many millions of times stronger than that of gravitation, but, like cohesive attraction, is incompetent to exert its power beyond very short distances, such as those measured by the limits of the molecule.

The correlation of physical forces has for its domain the interchangeableness and universality of the forces of Nature. It is competent to solve the dynamical problems of vital and physical phenomena, demanding from every antecedent its consequent, and exacting from every consequent an equivalency of antecedent. All sound experience of whatever kind justifies this affirmation. These views compel the idea of the universality of motion, and that force is the eternal causation of each and every phenomenon, and that the existing relations between matter and force remain constant throughout the universe. The same forces that whirl suns and planets in a restless march through shoreless space measure the phenomena of the moments of life.

The different consequents of molecular motion are sound, light, heat, etc., the antecedents of them all being some mode of motion. By the term "mode of motion" is meant the manner in which energies are made sensible to our understanding. Thus, the terms heat, light, etc., are but familiar ones by which we express the various modes in which force is exhibited to our senses in its action upon matter. Conservation of energy was denominated by Faraday as "the highest law in physical science which our faculties permit us to perceive." Its unfoldings mark an intellectual epoch which divides the old from the new. It teaches of the unity of the universe; it tells us how the sun's rays constitute the mighty energies of daily life and action upon every hand, warming, illuminating, and vivifying the surface of the globe.

As an illustration of this interchangeableness of force: suppose two files of men to be arranged in proper order, between which we roll a cannon-ball with a certain initial velocity. This ball runs the gantlet

of those files of men, it being the individual duty of each man to retard the momentum of the ball by interposing his hand in its path. It is evident that each hand so interposed will receive a shock, the force of which is just equivalent to the amount parted with by the ball itself. Finally, the ball comes to rest. The original momentum of the ball has for its equivalency the sum total of the lesser energies imparted to the several hands interposed. Or again, if, instead of hands interposed, we substitute a row of smaller balls, and let them receive the impact of the moving one, the result will be just the same. Each and every ball interposed will have the motion of its constituent particles augmented by an amount of energy of motion exactly equivalent to that parted with by the larger ball; and, when the moving ball finally comes to rest, the sum total of molecular energies in the interior of each ball is exactly equal to the original momentum of the larger ball. Thus we have an illustration of the transference of molar into molecular motion, the molecular motion making its appearance as heat, one of the modes of force. If you push endwise against a stick of wood, the force applied will immediately appear at the other end. This is transmission of force by means of molecular action. The force being applied to one end of the bar is transmitted from particle to particle with great velocity its entire length. If a row of bricks be properly placed, any force applied to the first of the row, sufficient to topple it against the next, will be transmitted throughout from the first to the last of the series. Or again, if the bar of wood be pushed against one end of our imaginary row of bricks, we shall have in the rod and in the falling bricks a continuous chain of similar phenomena, the action of the bricks being a *visible* illustration of the transmission of force, and highly analogous to that *invisible* transmission along the molecules of the bar.

Apart from the different modes of force, we have energy in two forms—static or potential, and actual or dynamic. The potential has been likened to a weight wound up, and the actual to a weight in the act of falling. The amount of energy expended in winding up the weight, less the friction, is exactly equivalent to the potential energy of the weight so raised, also to the dynamic energy given out by its falling or running down. The inherent measure of force possessed by each and every atom is its kinetic energy, and this energy is the correlative and antecedent of all the modes of force which characterize the various phenomena of the visible universe. The condition in which matter presents itself to our senses depends upon the degree in which these several forces are made manifest. All the phenomena of Nature consist in transformations of energy only, the working force of the universe being previously invested in the kinetic energy of its atoms.

The potential energies of the atoms of matter, in their free condition, are almost beyond human comprehension. Thus, heat a pound of charcoal to the point of incandescence. The vibratory motion of the atoms of carbon will then have reached an amazing velocity; oxygen

rushes in to form new compounds; the oxygen-atom, by its impact upon the coal, has its motion of translation converted into vibratory motion, which immediately appears as heat. The clash of these atoms makes up the sum total of the energies of the combustion. The actual amount of dynamical energy set free by the union of this pound of charcoal with atmospheric oxygen is equivalent to the mechanical raising of eleven and a quarter million pounds one foot high. Let us further consider the dynamical forces inherent in the molecules of free gases, and look to a molecular explanation of the three states of matter, the solid, fluid, and gaseous. In solids the atoms are held together with a rigidity that develops the full strength of cohesive force. In liquids the same attraction is so far lessened that a definite form can only be preserved in a limited degree, as in drops of water maintaining a spheroidal shape against the force of gravity. In the gaseous form atoms do not cohere, the cohesive force having been translated into the energy of motion, and it is this energy of motion which constitutes the expansive force of confined gases.

Suppose we have a vessel containing eight pounds of oxygen and one pound of hydrogen. This mechanical mixture of gases, invisible though it be, and harmless as it appears, is the theatre of energies wholly beyond our conceptions. Figure to your imagination these gases made up of atoms so small that a billion times a billion would scarcely fill a cubic inch, and all these atoms vibrating among themselves without actual contact. Although the minute distances over which these atoms travel are utterly immeasurable by direct appliances, we shall presently see that the energies evolved by the clash of their chemical union is something prodigious. The concussion of atoms at the union of eight pounds of oxygen with one pound of hydrogen sets free an amount of energy, in the form of heat, equivalent in mechanical value to 47,246,400 pounds let fall one foot, or the crash of a ton's weight as an avalanche down a precipice of 23,623 feet.

The three states of matter have been likened to three planes, of which the gaseous is the uppermost, the fluid occupying the intermediate plane, and the solid state for the lower one. The clash of atoms at the union of the two gases has resulted in the liberation of the energy above mentioned, but a change of state has taken place, and we now have water in the vaporous condition occupying the intermediate plane. This nine pounds of steam in condensing to water sets free an energy, the mechanical equivalent of 6,722,000 pounds let fall through the space of one foot. The next change takes us past the reduction of the temperature of the water from the boiling to the freezing point, setting free both the specific and latent heat of the water. This final fall to the plane of congelation occasions a further dissipation of energy equivalent to 2,237,256 foot-pounds, making a grand total of 56,000,000 foot-pounds as the measure of energy in our nine pounds of invisible gas.

The verity of these statements might be questioned were it not that

the most refined researches give unvarying results. Suppose we reverse this experiment, and, commencing with nine pounds of ice, we will, by a process of mental abstraction, again bring our conceptions down to the immeasurably small, and fix our attention upon the molecules of the ice. Figure to yourself the atoms of each molecule as being in oscillation through points of equilibrium. And, while your attention is centred upon the motions taking place in the interior of the mass, we will let fall upon the block of ice a concentrated beam of sunlight, and see how it deals with the inherent forces of cohesion and chemical affinity. The solar undulations impinge upon the molecules of the ice, and, under this bombardment of heat waves, see how rapidly the atoms accelerate their motions! All this while the contest is going on between the dynamic energy of the sun's waves of heat and the cohesive force of the molecules. Beautifully and symmetrically the forces of Nature built up the crystalline mass, and as silently and surely the sun's competency of heat will effect its liquefaction. Thus far we have seen the atoms accelerating in velocity by virtue of the energy imparted by the solar-heat waves, and all this time they are vibrating within the definite limits of the molecule. A further increase of heat will increase the motion of the atoms, thus tending to a rupture of the bonds of cohesive attraction. The struggle goes on until the ice melts, by which process we have solar energy conserved in the latent heat of water. The molecules being thrown almost beyond the range of cohesive force, their movements are no longer confined to their former limits, but may extend throughout the length and breadth of the mass. This is the fluid state. The amount of energy required to swing the atoms so nearly beyond the range of cohesive attraction, or simply to melt the ice, is equal to 500 tons raised one foot high. This force still exists as transmuted energy, and is the latent heat of water. A further addition of heat takes the form of increased vibratory action up to the boiling-point. Then comes another struggle seven times greater than the first. This last remnant of cohesive force of water must be surrendered, and the heat-energy necessary to perform the act is conserved or transmuted into the latent heat of steam. The last vestige of cohesive force now being gone, the molecules of steam are free to oscillate in all directions, and impinge against the walls of the containing vessel. If we continue the application of heat to the point of dissociation, the molecules of vapor will have acquired a momentum sufficient to rupture the bonds of chemical affinity. And here the energy required to separate the molecules of steam into its constituent atoms of oxygen and hydrogen is simply prodigious, being about forty-eight times as much as was necessary for the process of liquefaction. Thus the aggregated energies required to set free the oxygen and hydrogen in our nine pounds of ice are equivalent to the raising of a ton's weight 28,000 feet, and we now have the original nine pounds of gas, laden with the potential energies of 56,000,000 foot-pounds, which is just

equivalent to the requisite liberation of force necessary to reduce the gases back again to the solid form of ice. A cubic foot of water yields 1,862 cubic feet of the separate gases when at normal condition, and no human device is competent to overcome this expansion by pressure sufficient to reduce them back again to the liquid condition. Upon the evidence of Faraday we have it that "the decomposition of a single drop of water by electricity calls for an expenditure of more electromotive force than would suffice to charge a thunder-cloud."

Our main source of dynamic energy is from the sun. His energy is exhibited in every wind that blows, in every shower that falls, and in the history of every snow-flake—in the glare of gaslights, in the heat of the furnace, in the colors of the rainbow, and in the gorgeous sunset, in the beauty of vegetation and its silent growth. Thus, in an almost infinite variety of physical phenomena we see this transmutation of solar energy. This energy, after doing its allotted work, is in time dissipated into space by radiation. And, were it not for the intermediate position of the vegetable kingdom to check this degradation of energy and raise the elementary constituents from the chemical to the organic plane, man's duration here would be short indeed. The locking up of potential energy in the protoplasmic cell of the plant requires the expenditure of a vast amount of energy, but the solar ray, aided by the subtile alchemy of the leaf, is competent for the task; and, while the chlorophyl of the leaf assists in weaving organic tissues from the air, this outward dissipation of energy is delayed for a while, giving us food for our bodies and fuel for our fires. This final process of combustion once more converts these potential energies into the dynamic form and sets them free to dissipate into space. All the mechanical power which comes from the combustion of fuel and all the muscular force of the animal kingdom is but the transmutation of solar energy through the mediumship of plant-life. Well might we say, as did the pagans of old, "We are children of the sun." This flood of solar force is unceasing. Waves of ether may conduct a store of energies across the universe and invest them in a wealth of carbonaceous flora; these energies may lie dormant in vegetable fossils for untold eras; man may delve in mines and exhume the coal, and enlist the aid of oxygen to break the bonds of chemical affinity, setting free those energies stored away in the countless ages of the past; he may unfold link after link of the great dynamic chain of causation, and subject them to the scrutinizing analysis of the physicist; he may survey the rocks and tell us of their radiations of internal heat, or by his calculus tell us for how long in the past this planet may have been the theatre of life and death; he may tell us, not only of the energies in the atoms of a drop of water, but of a world of atoms—nay, more, of a universe made up of atoms with their energies drifting out into measureless space; but he can tell us naught of that unseen universe into which the energies of the visible creation are ever tending.

While dealing with the forces of Nature from an atomic standpoint, we are treading upon the border-land of science, beyond which all sensible phenomena have their origin.

Science may, by spectrum analysis, determine the constitution of the irresolvable nebulæ; it may tell us of the millions upon millions of ethereal waves necessary to impinge upon the retina to produce a given chromatic effect; it may measure the waves of air that roll as music down upon the tympanum of the ear: but *how* undulations upon the retina or vibrations of the auditory nerve are converted into consciousness of sight or sound, is a question which, like the causation and mystery of life, belongs to that realm outside of the domain of science—a realm the infinite mystery of which transcends all analysis!

In conclusion, let us not be led into a rigid belief that the present views of molecular physics are competent to explain all the phenomena that may be presented for solution for all time to come. It is enough to say that it answers our purpose in giving a satisfactory explanation of a large class of natural phenomena as they are exhibited to us in daily life. But, as we know the favored ideas of scientists and scholars in generations preceding ours have given way to newer and better ones, so, in turn, the popular conceptions of to-day may serve as stepping-stones to coming ideas, each destined to take its place as the predecessor of a higher and better intelligence.

EFFECTS OF ALCOHOLIC EXCESS ON CHARACTER.[1]

By J. MILNER FOTHERGILL, M. D.

A GREAT deal of attention has of late years been bestowed upon the subject of alcoholic indulgence. The importance of the subject warrants this, and even calls for still further attention. There are differences of opinion as to the use of alcohol; there are comparatively none as to the abuse of it. Leaving then, for the present, the question of the use of alcohol in disease, its effect upon the body temperature, and its position as a food, we may profitably engage ourselves for a little time with its social effects, alike upon the individual and the masses, especially in reference to its influence upon the mental manifestations of brain-activity. It is now universally acknowledged that mental alterations follow physical modifications of the brain, as seen in the various forms of insanity. We well know how profound is the influence exerted by alcoholic excess upon the brain, and through it upon the character. Unfortunately, the effects of continued alcoholic excess are but too frequently forced upon our attention.

[1] Read before the Social Science Congress at Liverpool.

The most pronounced product is found in the hopeless drunkard, who, in squalid rags, with rotten tissues, the embodiment of intellectual and moral degradation, utterly beyond hope, the line of possible restoration long past, hangs around the tavern-door, and, with the odor of alcohol floating on his breast, whiningly begs a copper from the mass of vitality around him, of which he himself is a withered and decaying branch. This man is incapable of labor; he is unwilling to entertain the idea of toil. He is beyond any capacity for labor; he is no longer capable of discharging his duty as a citizen; he is a social parasite of the lowest and foulest order, as useless as a tapeworm. He has abandoned all self-respect, because there is nothing left in him for himself or any one else to respect. He is a shameless liar, who will make the most solemn protestations as to the truth of what it is patent enough is false. There is no depth of moral degradation to which he will not descend for the means to purchase a little more of the fluid which has ever been his bane.

Betwixt him, however, and his patrons, many of whom enter the tavern to celebrate some little matter by a glass together, there is a potential association, not always at first sight readily apparent. The effect of alcoholic indulgence is seductive; and it often creeps on unobserved, doing much irretrievable mischief ere its presence is unmistakable. It is not the intention of the writer here to discuss the question of the moderate use of alcoholic beverages, but rather to point out the fruits, the evil consequences, of excess. Betwixt the hopeless drunkard and the casual taker of a social glass there are a thousand grades and modifications. Nor does it necessarily follow that the one shall degenerate into the other; very commonly he does not; but, unfortunately, he may, and not unfrequently does. Too frequently, indeed, the practice grows, especially in those who naturally lack self-restraint, or cannot control their impulses, however capable in other respects. The dangers of alcoholic allurement are various in their degrees of potency in different individuals.

Not only that, but there is no little influence exercised by the immediate motives for which alcohol is taken. The future progress of the individual indulging in alcoholic excess is widely different, according to the mental attitude at the time. Thus, betwixt the man who has been taking alcohol to excess at intervals extending over many years, and the young woman who is just commencing to drink because she is unhappy, there is a wide gulf. The one, so far as the alcohol is concerned, will probably live to an advanced age; the prospects of life in the other are very poor, and the ruin will be swift and complete. In the one there are long intervals of sobriety, during which the effects of the debauch will, to a great extent, wear off; in the other the act will be repeated as often as opportunity will permit; one act of indulgence will lead to, indeed will induce another, and the oft and quickly repeated act will become a constant habit, whose effects are soon felt.

It is not in women alone that the hopeless nature of drinking habits in certain susceptible organisms is manifested; it is equally seen in men where the nervous system lacks stability.

The deceptiveness, the utter untrustworthiness, the subtle craft, the falsehood, which women of culture even will develop under the influence of alcoholic cravings, have shocked many persons. The habitual drunkard, however produced, always exhibits these characteristic signs of moral degradation. The deterioration of character produced by protracted drunkenness is notorious. While the intellect becomes enfeebled by excess, the moral character becomes profoundly modified; the forces which ordinarily restrain others are in abeyance—perhaps too often their influence has gone forever; the indifference toward the interests of others progresses alongside a waxing selfishness, a complete absorption in self. So long as they can procure what they themselves crave for, confirmed drunkards are indifferent as to how others may suffer for, or be injured by, their selfishness. The ordinary feelings of parent or husband are too often overruled by the consuming passion; the wonted consideration for those who used to be dear to them has given way to an inordinate egotism. Not uncommonly, indeed, there is developed a vein of devilish mischievousness which delights in injuring those whom they ought to protect—a sort of malice, closely resembling the viciousness of certain animals. Of course, all drunkards are not exactly alike; the ruin still preserves the general outline of the primitive structure.

These statements may seem to some to be unnecessary as being already too well known, and too notorious to need any reference to them. But it is just because they are so well known and so indisputable that they are adduced here. Having thus laid firmly down the well-marked consequences of persistent alcoholic excess, it is possible to proceed to consider the less pronounced conditions, and to trace the course of the downward progress. It is evident that there must be many intermediate stages betwixt the commencement and the end of such a course—that some of the deteriorating effects of alcohol must be experienced long before the final stage is reached.

It may be well to speak in general terms of the indication of this direction, of this retrograding and degenerative process. The best subjects for the study of the social effects of alcoholic excess are furnished by the humbler classes: firstly, because the effects are more palpable among them with their limited resources, where excess in one direction means deprivation in another; and, secondly, because they present fewer complications, fewer elements of error to be encountered, than is the case in the more complex condition of affluence. It must not, however, for one moment be assumed that the evil consequences of alcoholic excess are confined to the humbler classes. No position in life will secure the individual against the unpleasant consequences of such self-indulgence, or prevent his reaping as he has sown.

A momentary digression may be permissible at this point; it will help to illustrate what is to be said shortly. In an elaborate paper on alcohol, read before the Medical Society of London last winter, by Dr. Lauder Brunton, F. R. S., to which was awarded the society's medal, it was stated that the first effects of alcohol are felt in the higher or controlling portions of the brain. The consequences are, that the lower or animal impulses manifest themselves, freed from the control to which they are ordinarily subject. Such are the first symptoms of intoxication, after the stage of exhilaration has been passed. Then the motor centres are implicated; and complex movements, like walking, ordinarily habitual, require a conscious effort for their execution, and even then the performance is imperfect. After this the lower portions at the base of the brain are involved, leaving nothing but the respiration and the circulation in action; while still further intoxication arrests these movements, and the organism perishes.

It is this effect upon the higher centres of the brain which induces the most disastrous social outcomes of alcoholic indulgence. The person who takes alcohol to excess becomes a lower form of being by comparison with those around him. This is seen alike in the individual and in the aggregate. There is a diminution so brought about in the power to exercise self-control, and to estimate aright the claims of the future upon the present; there is produced a state of thriftlessness and recklessness, and a lack of consideration for others. These effects are demonstrated distinctly in two out of many practices. The one is that form of improvident self-indulgence—early and premature marriage, where the rite is robbed of all sacredness, and degraded to a mere form of license for unrestrained indulgence. This is common in the pit districts of Durham, where comparative children present themselves to be married, who can scarcely have realized the gravity of the step they are taking. Another form, sadly too common, is that of living in any hovel where the rent is small, so that a larger sum weekly remains over to be spent in drink. This is especially found amid the Irish in towns. The moral effects of decent houses, with sufficient sleeping accommodation for the two sexes, are well known; the disastrous immoral effects of huddling different sexes and ages together, from want of proper sleeping-space, are equally notorious. Not only are these evil consequences of such overcrowding produced, but, when alcohol gives the rein to the passions, these consequences are aggravated and intensified. There are then blended the direct and the indirect outcomes of alcoholic excess, each of which aggravates and adds to the other.

It is unnecessary to multiply illustrations of the deterioration of character induced by alcoholic indulgence. Just one more may be adduced. When recently on a visit to the South Yorkshire Asylum, near Sheffield, Dr. Mitchell, its accomplished superintendent, informed me that even in the victims of mania and general paralysis there was a marked contrast in the degree of violence manifested betwixt the pa-

tients arriving from the purely agricultural districts and those from the iron-work and colliery districts. This he attributed partly to their rougher ways and to the nature of their occupations, but still more to the drinking habits of the latter. That these last formed the chief factor in the production of the result was rendered probable by the large proportion of female subjects of general paralysis in that asylum. This disease is comparatively rare among women; and its prevalence among females from these districts Dr. Mitchell attributed to the habits of the women being allied to those of the men, especially as regards indulgence in drink.

Such, then, are some of the grave social outcomes of systematic indulgence in alcohol which arrest our attention. We have seen that its effects upon the nervous system are such as to give the rein to the lower centres, chiefly by lessening the control exercised by the higher and restraining portions of the brain. Man escapes from his wonted self-restraint when under the influence of alcohol, and stands before us with his fundamental character revealed. The groundwork of his character is exposed by the removal of the demeanor which he has carefully cultivated. The outside cover is withdrawn; all, or nearly all, that self-education or cultivation has given, is temporarily taken away. Through the revelations so made by alcohol we not rarely find that even in staid and proper men the tiger and the ape have not entirely died out. The animal propensities are thus discovered to have been concealed rather than subdued. For the time being the intoxicated individual is reft of much that not only he but his ancestors for generations back have studiously cultivated. For the time being he is a lower type of man. About the truth of this statement there can be no doubt.

The progress of physiological psychology, of the investigation of the workings of the mind, has taught us, in unmistakable accents, the strong tendency which exists for a habit to be formed by repetition of anything. After a thing has been done several times it becomes exceedingly easy to do it again. There is, in fact, in the nervous system a great readiness to take on an attitude which has been assumed before. We all recognize how it becomes necessary for every one to rehearse a part before acting it, and how quickly a species of habit or imitative attitude is formed. It is widely recognized that practice makes perfect, and that what was once difficult becomes easy by repetition of it. These are but illustrations of a law universally acknowledged. We all know how important it is to avoid what may become a habit. Consequently, we can see distinctly and with painful clearness that repeated indulgence in alcoholic stimulation, not necessarily extending to visible intoxication, must tend, by virtue of this law, to modify and mould the character. Under alcohol the individual becomes sanguine, reckless, careless of consequences, boastful, and indisposed to sober calculation; he also becomes self-assertive, arrogant, and boisterous; there exist a certain impulsiveness and impatience of control, and a distinct

tendency to reach certain ends by violence, if other measures do not seem likely to be successful. In fact, we see the habitual self-restraint slowly developed by the exertions of many ancestors, by the efforts of the individual himself, aided by the training given by education, for the time being withdrawn to a great extent. Every time this act is repeated the greater the tendency for the character to manifest its lower rather than its higher forms. The character is indeed being slowly modified, and that, too, in a most undesirable direction. It is being gradually deprived of much that a slow process of civilization has given it.

It must be patent to all that the direction just depicted is that in which our town populations are distinctly moving. I have sketched elsewhere (the *Alliance News*, July 22 and 29, 1876) those circumstances in the condition of the masses which, in my opinion, render something more than the mere removal of temptation necessary in the practical treatment of intemperance. Whatever may be the effect of monotonous occupations, of bad hygienic surroundings, of improper food in infancy, and the physical deterioration which results from large aggregations of individuals, there can be no question but that repeated alcoholic indulgence is gradually modifying the character of the masses. It is seen in the growing insubordination, in the turbulence, the impatience of control, in the tendency to assert their opinion on subjects of which they are not in a position to judge; it is demonstrated in the growing thriftlessness, in the marked inclination to increase the number of their holidays, in the spending of a large portion of their weekly earnings on Saturdays and Sundays, till the middle of the week is a time of comparative destitution. It is illustrated by the columns of our daily press in the increased acts of violence perpetrated under the influence of alcohol by men accustomed to be intoxicated; and by the increase of disease of the nervous system, especially excitable forms of mania, found most commonly amid the population of certain industrial districts. Doubtless there are many thrifty, sober, self-respecting, and industrious working-men; but it cannot be denied that the proportion of such men to the whole body is less now than it was in days not far gone by. The character of the masses has been undergoing grave modifications in recent times; and the fashioning hand of alcohol can be clearly traced in the production of the results.

There is, however, a still grimmer aspect of this subject than even the effects of repeated indulgence upon the mental attitude of the individual himself, and that is the influence which such indulgence will and must exercise upon the nervous system of his offspring. We are all of us "the outcome of the coöperation of countless ancestral forces," and each of us is individually indebted to his ancestors for every act of self-restraint, every act of self-denial or control exercised by each of them. Our forefathers, in forming their own character, were insensibly fashioning ours. "The fathers have eaten sour grapes, and the chil-

dren's teeth are set on edge," is sternly true. What, then, can we legitimately expect to be manifested in the next generation? Further, if children are taught to frequent taverns, and drink there on holidays and Sundays, by their fond but foolish parents, what effect must this exert upon the character during the plastic period of youth and growth? How far are the inherited mental constitution and nervous system, already depraved to start with, still further modified by such experience of the individual in childhood, when "wax to receive but marble to retain?" Conditions already hard enough upon the child are aggravated by indiscretions perpetrated toward the infant before its own free will and choice can be called into play, before it is responsible for its own actions. Not only have its parents given it an imperfect organization, but they are prejudicing its chances of self-evolution before it has had an opportunity of forming its own decision—it is handicapped alike by descent and by mischievous early training.

The habit of frequenting taverns, of drinking, and of feeling the self-satisfaction so induced, leads to still further indulgence in alcohol by half-grown youths; and so the inherited character is still further deteriorated. The increasing loss of self-control leaves such beings less and less capable of resisting the temptations, the allurements of the public-house. The impulsive and less perfectly controlled nervous system craves more and more for the alcoholic stimulant; and the longings are intensified accordingly. The repeated visits to the tavern grow into a custom, and what commences as an irregular practice becomes crystallized into a habit.

Nor is it in youths alone that the drinking customs of the day are seen in their evil and sombre aspects. The number of respectable girls seen now at public bars is a contrast to what obtained but a few years ago. Up to a recent period, if a girl were known to frequent taverns, her character was gone; and it was rarely that a well-conducted girl was seen in a public-house, and then only with her sweetheart or some male relatives. But now it is sadly different. From familiarity with bars as an outcome of excursions, and even more from the associations of the music-hall, girls, capable of better things, are not now apparently conscious of any impropriety in being in a public-house without male friends; and the painful spectacle of seeing young girls under twenty treating each other at a public bar is a sadly too common occurrence. How can a girl, with the mobile nervous system of her sex, be fitted to be a mother, and to counteract the evil tendencies of alcoholic indulgence in the father, if she herself have been subjected to the same influence? With the facts of inheritance before us, what may we expect, what must we apprehend as to the condition—the future prospects—of the generation following immediately after this one? As our forefathers insensibly and unconsciously built up the character of the present generation, so it, in its turn, is fashioning the character of its successors, its unborn offspring. No wonder, then, that the *morale* as

well as the *physique* of the masses in large towns is undergoing already retrograde changes; and that the present condition fills the minds of observers of social progress with gloomy forebodings as to the future. The progress of civilization has endowed us with a measure of self-control, has tended to subordinate the unit of the mass—to encourage the evolution of the citizen as compared to the mere individual. The effect of alcoholic indulgence to excess is to institute retrogressive changes, and to undo, to a great extent, what civilization has slowly achieved.—*Sanitary Record.*

SKETCH OF GUSTAV WALLIS.

GUSTAV WALLIS, the indefatigable traveler and botanist, whose death at Cuenca, Ecuador, we recently announced, was born May 1, 1830, at Lüneburg, Prussia, where his father was an advocate and proctor of the superior court. He died at the early age of forty-eight years, of which the last eighteen were spent in incessant travel and research. We have not been able to learn any particulars concerning the early life of this distinguished traveler, for the compilers of biographical dictionaries have utterly ignored the man whose merit is simply that he has enriched horticulture with no less than one thousand new species. And here we may remark that works of the class just named are as a rule singularly neglectful of the representatives of science: while every divine and politician that rises ever so little above the average of his class is mentioned, scientific men whose fame is world-wide are passed by in silence. For the biographical items contained in the present sketch we gratefully acknowledge our indebtedness to our German contemporary, *Die Natur*, in which is published a brief but appreciative memoir of Wallis by his friend Dr. Karl Müller, editor of that very able magazine.

Wallis's travels in quest of botanical rarities began in 1860, his first field of labor being the same which, with the exception of two years, engaged his attention down to the day of his death—tropical America. In that year we find him exploring the banks of the Lower Amazon and a few of its principal tributaries, the Tapajos, Madeira, Purus, etc. In 1863, quitting the course of the great stream, he made an excursion northward, crossing the Rio Negro and the Rio Branco and penetrating to the Sierra Parima on the southern frontier of Venezuela, in longitude west 64°, and nearly under the equator. Returning to the Amazon, he explored the left bank for some distance up-stream; then swimming across the river, he followed the right bank westward into Peru and Ecuador, crossing the Cordilleras, and in 1866 arriving at the city of Guayaquil. Here he took ship for the port of Buenaventura in the

Colombian State of the same name; and thence, after exploring the coast Cordillera of the State of Choco, visited the valley of the Cauca. In 1867 he reached Panama and explored the Isthmus up to the volcano of Chiriqui. Turning back he traveled along the northern coast of Colombia till he reached the State of Santa Marta, and then turning south he crossed the Sierra Nevada, and made his way to Santa Fé de Bogotá, traversing the intermediate provinces. In the same year (1868) he sailed on his return voyage to Europe, having traversed the whole extent of tropical America from north to south. He reached his German home in a state of complete physical exhaustion, as very plainly appears from the photograph taken at this time, of which our engraving is a copy.

Hitherto he had been in the employ of a well-known horticultural establishment in Brussels, that of Linden; but in 1869 he received a commission from the London house of Veitch & Co. to visit the Philippines on an errand similar to that from which he had so recently returned. He accordingly took passage for the United States, traveled overland to California, and thence reached Manila by way of China and Japan. He specially studied the mountain-chains of Luzon for plants and other natural-history specimens. In 1871 he returned home by way of Singapore and the Suez Canal.

Before the year was at an end he was again *en route* for the tropical regions of South America. These countries had cast their spell upon him, and he could with justice say that, of all botanical travelers, he knew them best. At the same time he was in hopes that he might be able to visit and botanically explore a region that was in bad repute, owing to the hostile character of the neighboring Indians, viz., the "Pongo de Manseriche"—the grand rocky chasm through which the Marañon forces its way. He had once before approached very near to this locality from the Ecuador side, but had been obliged to give it a wide berth, the natives manifesting their hostility. But his explorations this time extended only to the Paramó country in New Granada, and in 1872 he went back to Europe. This expedition was made at the expense of the house of Linden. Again he explored the elevated mountain-chains of the United States of Colombia; and finally, at his own charges, he began an exploration of the Pacific coast of Ecuador.

The hardships endured by Wallis during these fifteen years of constant pioneering in tropical forests and swamps finally undermined his strength, and he was seized with a complication of diseases. He died, penniless and friendless, in the hospital of the Sisters of Charity at Cuenca, Ecuador, on the 20th of June, 1878.

CORRESPONDENCE.

IS YELLOW FEVER ENDEMIC IN THE GULF STATES?

To the Editors of the Popular Science Monthly.

GENTLEMEN: Mr. L. C. Fisher, of Galveston, Texas, has seen fit, in a recent pamphlet,[1] to attack my article on "Yellow Fever," published in the October number of your valuable magazine, with considerable warmth and even asperity. He considers himself aggrieved by the statement that yellow fever is endemic in the cities of the Gulf and South Atlantic coast. If the gentleman wishes to enter into a controversy on the subject, I must certainly decline to meet him, for two reasons: first, because your space is too valuable for interminable discussions; and, second, it is a matter of general experience that arguments on professional questions with non-professional persons are very unsatisfactory. A few explanatory words, however, I may be allowed to say, and further than this I shall decline to discuss medical questions with a layman.

He says, "If it is only endemic in the Gulf and South Atlantic cities, will Dr. Tracy explain why the disease appeared in Boston and Philadelphia so many years before it appeared in New Orleans?" The answer is a simple one. It was brought to the Northern cities earlier because of their earlier commercial relations with the West Indies, and the difference in the two cases is, that the disease never appears in the Northern cities unless it is imported, while in New Orleans it has never left the city since it was first brought there. New Orleans was exempt up to 1796, but, according to Dr. J. C. Nott, "from that time to the present (1870) there has never been a single year without sporadic cases when they escaped epidemics." Mr. Fisher appears to have the idea that a disease cannot be called endemic excepting where it originates *de novo*, like the malarial poison, for instance. In this sense it cannot be proved that yellow fever is endemic anywhere; for, however it may have first started, it is now the accepted belief that it only occurs as a result of previous cases, and it is fairly said to be endemic in places where the poison does not appear to have ever been destroyed since it was first brought to them. The occasional dormancy of the disease does not imply its extinction, for there is no place in the world where it rages as an epidemic the year round.

[1] "Yellow Fever's Origin. The Disease not Endemic in this Country." By L. C. Fisher. Galveston, Texas.

Mr. Fisher is also perturbed in spirit because I spoke of yellow fever as "beginning its march" and "following watercourses and lines of ocean-travel." He thinks a metaphor out of place in a scientific article, and suggests that "a truly scientific physician would say yellow fever, or its germs or fomites, is carried," etc. The use of metaphor is of course a matter of taste. He does not like it. I do. And that is the end of it. But when he attributes to the "truly scientific physician" such an expression as the fomites of yellow fever, he shows that he is getting out of his depth. Let him look up the word fomites and see what it means.

His suggestion that my unpretending article was the result of a deep-laid plot to ruin the commerce of Southern cities is really too funny for sober consideration. Why did he not go a little further, and accuse me of ulterior designs on the throne of Mexico?

I am sure I should be the last to wish to injure the prospects of any section of our country, and if the present efforts to establish a national quarantine should be successful, and the disease should actually be exterminated in our Southern cities, I should be very much gratified. But, until that is accomplished, I may surely be allowed to have my own opinion on a question on which opinions are, and always have been, so much divided, and to believe that quarantine alone will not banish yellow fever from our Gulf cities at least. Mr. Fisher's energy and earnestness in the matter are to be highly commended, however, and I certainly shall not try to put any obstacles in his way, however much I may disagree with his theories. Yours, very respectfully,

ROGER S. TRACY.

NEW YORK, *November* 18, 1878.

SCIENCE LECTURES IN JAPAN.

To the Editor of the Popular Science Monthly.

MY DEAR PROFESSOR: How I wish you were here to see the eager way in which an audience of intelligent Japanese listen to lectures from their own countrymen and from a few of us who have been fortunate enough to be invited to address them!

I have just finished a course of four lectures on Darwinism. Mr. Kikuchi, a native professor in the university, and a graduate of Cambridge, England, and a wran-

gler besides, interpreted for me. I had my blackboard and chalk, and did my best to make the principles of natural selection clear. As soon as I can write them out they will be published in Japanese, with illustrations, which I shall draw as far as possible from Japanese animals. Prof. Penollosa, one of the new foreign professors at the university, follows with a course of four lectures on the evolution of religions.

It seems such a delight to these people to find that there are some other views held abroad besides those taught by the missionaries, and the hearty way in which they applaud shows how welcome rational views are.

Prof. Mendenhall, of the university, formerly of the Ohio State University, will give a course of lectures on the magnet, capillarity, gravitation, and other subjects, before the same audience—Mr. Agee, the originator of the course, interpreting for him. All the money raised in this way will be devoted to building a lecture-hall in Tokio.

At present the lectures are given in a large tea-house on Sunday afternoons—the large audience seated in the usual Japanese fashion on the floor, with boxes of hot coals here and there for the convenience of pipe-smokers. The audience have presented to them from four to five lectures succeeding each other, with but a few minutes' intermission between each lecturer. Their endurance in this respect is remarkable. I hope to lecture for them repeatedly during the winter.

Faithfully yours,

EDWARD S. MORSE.

TOKIO, *November* 10, 1878.

EDITOR'S TABLE.

PROTECTION AND SOCIALISM.

THOSE who study the influence of legislation in a careful, dispassionate way, and merely as a problem of science, will soon be struck by two things: first, that laws frequently fail to produce their expected effects; and, second, that they give rise to many results which were not at all anticipated. There are various reasons for this; among which are the intrinsic difficulties of a complex subject, false notions in regard to it, and the arrant incapacity of the men who deal with it. In the first place, human society is regulated by laws of its own, which cannot be suspended in their operation by civil interference, and which are, moreover, highly complicated and often obscure and unresolved. And when to the complexities which belong to each locality there are superadded the diversified conditions — climatic, industrial, and racial — which pertain to a vast region of country, the complication of social forces is vastly augmented. Even the most powerful minds, after long application to the subject, are unable to grasp these multifarious conditions so as to know how laws will take effect. Hence the ablest thinkers on social matters are the most cautious, and have least confidence in the production of social good by legislative projects.

But even in those cases that are sufficiently understood to make knowledge valuable for the law-maker's guidance, it is difficult to get the actual benefit of it. Our "legislative wisdom" is too apt to be swamped in legislative folly. There are prevalent superstitions about the dignity, and grand offices, and mysterious potencies of government, which lead people enormously to exaggerate what can really be got out of it. Stripped of this glamour, what is popular government at any time but the office-holding politicians that have been got together to represent and embody it? Constitutions and laws derive their value and virtue from the competency and character of the men chosen to interpret and apply them. If these are low, legislation will be degraded. What government is and does is determined by the quality of those who carry it on. The American Congress is invested with power to abolish past legislation and substitute new legislation;

but who will pretend that it is constituted of men capable of comprehending even the rudimental interactions of social forces, much less the far-reaching consequences of experimental legislation? A large number of them are illiterate blockheads, who have never seriously studied anything—men who have made money and used it to get office. Many Congressmen are mere practised political bullies and intriguers. Many are shrewd lawyers who know the technicalities of their profession, and but little else. Others are educated men, but in whose education no science of any sort ever entered. And there are a few Congressmen of able minds, who have critically studied the facts and principles relating to human society which should underlie sound legislation. But they are precious few; their chances of getting into Congress are slender, and of remaining there next to impossible—even if their self-respect would permit them to wish it. And what chance would really profound men have of influence upon the congressional body? He who speaks of distant results, and the indirect operation of measures, is pooh-poohed as an abstractionist and an impracticable. The statesman is the man of far-sighted forecast, who can act with a reference to remote results; the politician recognizes only that which is direct, immediate, and palpable, such as foolish constituencies can appreciate, and of such is our national Congress mainly made up. If a man of mental grasp and force should undertake to discuss questions of social interest from the scientific point of view, he would not be understood, could not be followed, and would be voted a bore by the majority of mediocrities in the assemblage. Hence the neglect of those remote but often potent consequences of legislation of which short-sighted partisans are apt to take but little account.

An illustration of this is furnished by the long congressional treatment of the subject of "protection." The protective policy has always been defended and urged on the lowest grounds of immediate, palpable, pecuniary advantage, such as unthinking and sordid people can best appreciate. How such legislation will affect this or that business, or operate in this or that locality, has ever been the vital consideration that has obscured all other considerations. What is to be the ultimate outcome of protective legislation in its wide, indirect, subtile influence upon the minds of the people is a question which our national law-makers have not troubled themselves to investigate. Yet agencies that act quietly and take time to develop are often the most momentous at last. Congress has been busy with inquiries as to how tariffs would affect trade and manufactures, but it has had no concern about the habits of thought that the protective system might finally engender among the people. Yet we now begin to be confronted with this serious question. That there is a tendency to the spread of socialistic and communistic doctrines in this country is undeniable; and it is equally certain that the fact inspires grave anxiety on the part of thoughtful and conservative men. Notwithstanding our popular educational system, our numerous colleges, our abundant newspapers and cheap books—unparalleled agencies for the diffusion of intelligence—doctrines are making headway, and are extensively accepted, that threaten the entire subversion of our social fabric. It has not needed much acuteness to connect communistic tendencies with the system of paternal care-taking and protective government which has been growing in strength in this republic for many years. But an English writer of ability on economical questions has lately presented this matter in a way that will command the attention of reflecting people. Prof. Fawcett, who occupies the chair of Political Economy in the University of

Cambridge, and is besides an author on economical subjects, and a member of the House of Commons, has published an article in the *Fortnightly Review*,[1] "On the Recent Development of Socialism in Germany and the United States." He takes the ground that this development is but the natural result of the doctrine of unlimited state functions, and the extravagant notions of what government is capable of accomplishing, which are widely disseminated in both of these countries. In Germany, paternal government, centralization, bureaucracy, and compulsory military service, all conspire to fix deep in the national mind the idea of the omnipotence of the state, which has therefore only to exert its power and it can confer boundless good upon all its subjects. In this country governmental care-taking is most conspicuous in that protective system by which the people's industries are taken charge of by the state. The notion is thus fostered that the people owe their prosperity to the Government, and from this the inference is ready that the state is responsible for their prosperity. But the logic of protection does not stop with its application to business; if it can help people materially it can also help them mentally, and so the belief is now widely maintained that the state *owes* every citizen an education. With so much conceded, the socialist has no difficulty in drawing still further conclusions in the same direction, and so he plants himself at last on the high protective ground that Government shall take possession of all property and take care of everybody. After a careful survey of the claims of socialists and communists as shown by their works, and the proceedings of their Congresses, Prof. Fawcett sums up their programme in the following propositions:

"1. That there should be no private property, and that no one should be permitted to acquire property by inheritance. That all should be compelled to labor, no one having a right to live without labor.

"2. The nationalization of the land, and of the other instruments of production; or, in other words, the state should own all the land, capital, machinery—in fact, everything which constitutes the industrial plant of a country, in order that every industry may be carried on by the state."

[1] Reprinted in THE POPULAR SCIENCE MONTHLY SUPPLEMENT for December.

The essence of socialism is thus the subversion of private independence and the substitution for it of entire dependence upon the state; that is, the protection of the citizen is to be no half-way matter, but thorough-going and complete. Carried to this conclusion, the doctrine is of course palpably absurd and insane, but have the people not been actually educated toward it by the established and extending doctrine of state omnipotence and protective guardianship of the people's business interests? It is now demanded that the state shall be simply consistent, and carry out its policy. The state has already far transcended its legitimate function of protecting the rights of its citizens by the enforcement of justice in social relations. It has, in fact, neglected and half forgotten this legitimate and incumbent duty in its zeal to take care of those interests and affairs of citizens with which it has no concern, because they are parts of the liberty and responsibility of individuals in free society. Yet this meddling policy of Government is undoubtedly strengthening, notwithstanding its multiform evils. We are boastfully told that the protective system is not declining in this country, as is evinced by the fact that fourteen hundred articles of commerce are the subjects of protective taxation, so that the prices of almost every purchasable thing are dependent upon legislation, while the people acquiesce in the policy as wise and proper. But this is only so much vantage-ground for the communist who demands the enlargement of the system on the basis of its

acknowledged benefits. As Prof. Fawcett justly remarks:

"Each fresh extension of the principles of centralization or of industrial protection may be regarded as directly promoting the growth of socialistic ideas. A people who from their earliest childhood are accustomed to believe that state management is better than individual effort, will not unnaturally think that, if they can place themselves in a position to control the state, they will then possess a power which will enable them to redress every grievance from which they are suffering, and to remedy everything which they may regard as unsatisfactory in their condition."

No doubt these radical communistic claims are too wild and ridiculous to be entertained by intelligent and sober-minded people, but many people are neither intelligent nor sober-minded. There is of course no danger that their programme will be carried out, but grave mischief cannot fail to result from the diffusion of such poisonous and destructive notions, and we are now compelled to consider to what extent Government is not itself chargeable with having fostered and encouraged them. At any rate, the honest advocates of the protective system may be led to consider whether it is not productive of an order of evil consequences not foreseen by the politicians who have maintained it.

THE RELIGIOUS RECOGNITION OF NATURE.

Prof. Joseph Henry was a religious man as well as a man of science. He wrote a brief letter to a friend just before his death, suggesting at its close that it is in the "line of theological speculation;" and being an eminent scientist, his religious views are so prized by religious people that this letter has been printed as a tract for gratuitous distribution, and is to be had at the American Tract Society, 150 Nassau Street, New York. It is an encouraging sign of the times to see devout people showing in this way an increasing appreciation of the importance of the beliefs of scientific men concerning theological matters. We heartily commend this practice, for if theological discords are ever to come to an end it must be by the substitution of scientific ideas for dogmatic creeds. The sects will ultimately harmonize just in proportion as they absorb scientific truth.

Prof. Henry did not live to revise his letter (usually a careful habit with him), and it therefore has the interest and value of a spontaneous private expression of his convictions, and it was made, he says, "without stopping to inquire whether what I have written may be logical or orthodox." With this candid carelessness about his orthodoxy we entirely sympathize, and are here interested in this unconstrained avowal of his religious views because of their relation to science.

In the true scientific spirit and method he begins by looking out upon Nature and regarding it as presenting problems that require to be solved. Largely viewed, we are in the midst of its mighty movement; we are a part of it; we emerge and quickly disappear—what view shall we take of it? on what hypothesis explain it? Among the various theories of the universe he accepts the theistic theory as the "simplest conception," and giving the most satisfactory account of things. His solution is that the order of the world is originated and directed by a Divine Being who has made man with a capacity of understanding the universe by means of science. As his own statement is important, we quote his words:

"We live in a universe of change: nothing remains the same from one moment till another, and each moment of recorded time has its separate history. We are carried on by the ever-changing events in the line of our destiny, and at the end of the year we are always at a considerable distance from the point of its beginning. How short the space between the two cardinal points of an earthly career, the point of birth and that of death; and yet what a universe of wonders are presented to us in our rapid flight

through this space! How small the wisdom obtained by a single life in its passage; and how small the known when compared with the unknown by the accumulation of the millions of lives through the art of printing in hundreds of years!

"How many questions press themselves upon us in these contemplations! Whence come we? Whither are we going? What is our final destiny? What the object of our creation? What mysteries of unfathomable depth environ us on every side! But after all our speculations, and an attempt to grapple with the problem of the universe, the simplest conception which explains and connects the phenomena is that of the existence of one spiritual Being, infinite in wisdom, in power, and all divine perfections; which exists always and everywhere; which has created us with intellectual faculties sufficient in some degree to comprehend his operations as they are developed in Nature by what is called 'science.'"

Prof. Henry here begins with Nature, and deduces from its study the fundamental conception of religion—the idea of a Divine Spiritual Ruler of the universe, who has made man capable of penetrating its secrets and understanding its laws by the faculty of reason applied to scientific investigation. Nature, God, religion, and science, are thus bound together in one grand synthetic and harmonized conception. In this view Prof. Henry represented the most advanced intelligence of his time, and how advanced *was* his view we can best appreciate by contrasting it with other states of mind in the theological sphere.

It is well known that, in the language of a recent writer, "the men of the first Christian generation, including the apostles and the writers of the New Testament, lived in the almost daily expectation of the Lord and the end of the world." The notion of the world's coming to an end was an easy one in a state of perfect ignorance of the nature of the world. When it was supposed to be flat and small, and stationary, and there was no such idea as that of the universe, and not the slightest conception of anything like order and stability in the constitution of sublunary things, there was certainly no reason why the world should not come to an end at almost any time. It was supposed to have been made in a somewhat hurried manner, not very long ago, and it was natural to think that it might terminate at almost any hour in a similar sudden way. And, as its creation was considered as belonging to theology, its extinction, it was supposed, would come by a theological catastrophe. The idea that the world might come to an end was made possible by the ignorance of the time, and as men knew nothing about its shape, magnitude, motions, relations, and antiquity, they could not be expected to know anything in favor of its duration. No blame can therefore be attached to the primitive Christians who were in daily expectation of the end of the world.

But when we pass over a period of eighteen hundred years and reach the nineteenth century, the case is different. It is not surprising that the early traditions should have long been tenaciously held in the sphere of theology, but it certainly is a matter of some amazement that a belief in the predicted destruction of the earth as the sequel of a theological programme could have been seriously entertained so late as the middle of the present century. Yet the sudden ending of mundane affairs in accordance with Scripture predictions was not only profoundly believed by multitudes, but the exact time was assigned and extensive preparations made for the grand event. The epidemic of Millerism spread over large parts of the country not many years ago, and, although the exact calculations were discredited, revised calculations took their place, and societies of "Second Adventists" in different parts of the country have kept alive the exhilarating prospect that the earth would soon be wrapped in conflagration, and, if not reduced to nothing, that the

terrestrial order would at any rate come to an end.

A Second Advent Convention has recently been held in New York, which was devoted to a modified form of this old doctrine. A church was crowded with its adherents, coming from all the religious denominations in various parts of the country, and the subject was discussed for days with great fervor and enthusiasm. Nothing was said in the proceedings about the end of the world, but they were redolent of the expectation of great supernatural events which it was supposed by many may happen at any time. A great array of theological talent was present, and many learned disquisitions were read. The conference was Pre-millenarian in sentiment, and Dr. West, a Presbyterian clergyman of Cincinnati, explained the doctrine as follows: "Christian Chiliasm, or Pre-millenarianism, is the doctrine of the personal reign of Christ one thousand years after beast, false prophet, and apostate Christendom, have been judged and perished in a common doom. It is the doctrine of a visible and external sovereignty of Christ upon earth as the outcome of history, the redeemed church of all ages rejoicing in the fullness of a resurrection-life, in the actual presence of Him who is the 'Prince of the kings of the earth'—a kingdom of outward glory established upon the ruin of the polities of all nations wide as the canopy of heaven."

Furthermore, "Pre-millennialism is a protest against the doctrine of the unbroken evolution of the kingdom of God to absolute perfection on earth apart from the visible and miraculous intervention of Christ. It is an equal protest against that vapid idealism which volatilizes the perfect kingdom into a spiritual abstraction apart from the regenesis of the earth."

What Dr. West here understands by "vapid idealism" and volatilizing the kingdom into a "spiritual abstraction" is simply a protest against the enlarged interpretation of Scripture passages in which many modern theologians are inclined to indulge. The convention went unanimously for the literal meaning of Biblical texts. "Outside of its lids" (the Bible), said Dr. Tyng, Jr., "we decline to follow our disputants." Again: "One verse in every twenty-five or about three hundred verses of the New Testament speak of this future event." Dr. Goodwin planted himself "on the self-sufficiency of the Scriptures to explain themselves." The discussion throughout was filled with theological technicalities, the import of adverbs and pronouns, the rendering of Greek and Hebrew passages, and the ransacking of Biblical books from the Pentateuch to the Apocalypse for hints, allusions, and declarations, that might be made to sustain the hypothesis to which the body was committed.

We refer to all this merely as a curious and instructive phenomenon of our times. There was but one reference, as we observe, to science in all the proceedings. A distinguished clergyman remarked: "Look at that audience; you can't get such a gathering at secular conferences. Why, at a scientific convention a paper an hour long nearly always succeeds in thinning the audience down to the specialists in the topic of which it treats." This observation seems to have exhausted the entire interest of the convocation in scientific matters. All the knowledge that has been developed in the last five hundred years regarding the order of the world was as so much idle wind to these Second Advent theologians. Prof. Henry, as we have seen, began his theology with the consideration of Nature; this conference neither began with Nature nor ended with it, nor made any more reference to it than as if it had been composed of disembodied beings who had never heard of natural things. Though their theories were maintained as taking effect upon

human life and the earthly destiny of humanity, there was not a reference to the natural world as being in its existing order an embodiment of Divine wisdom, or entitled to the slightest serious consideration. In fact, the whole scheme of doctrine put forth was impliedly based upon the old assumption that Nature belongs to Satan, and deserves destruction as the embodiment of all sin. Dr. Brookes, of St. Louis, discussed the doctrine of the convention in relation to the fall of Adam and the universal curse that it entailed, saying, "From that day to this the curse has smitten the old and the young, the rich and the poor, the king and the peasant, the philosopher and the savage alike, and diffused its virulent poison through the whole system of Nature."

It is clear that a great deal is yet to be done before such enlightened opinions as those of Prof. Henry become accepted and assimilated in the religious world; and such conventions as this of the Second Adventists are extremely useful as indicating the amount of conscientious ignorance that has yet to be overcome before the scientific truths of Nature are even so much as recognized.

IMPROVED DOMESTIC ECONOMY.

The Princess Louisa received an address from a deputation of the Ladies' Educational Association of Montreal, and they got from her a very sensible reply. But what will the operators of our fashionable girls' schools and of our female colleges and normal schools say to the closing observation of this royal and court-bred lady, which was as follows: "May I venture to suggest the importance of giving special attention to the subject of domestic economy, which properly lies at the root of the highest life of every true woman?" This is a momentous truth; none the more true, of course, because uttered by a princess, but perhaps some will be induced to reflect upon it on account of the distinguished source from which it comes. For if what the princess here says is correct, our schools for the education of women are very far from what they should be. Domestic economy, in its full significance as a foundation of the highest life of woman, happens to be just the one particular thing which our female boarding-schools, colleges, and normal schools systematically avoid. They learn languages, and history, and algebra, and music, and many other fashionable things, but the science of domestic life and the art of home-making find no place in the feminine scheme of studies. Here and there a little attention is paid to it, but it nowhere has the rank and importance which is rightfully its due, and which this most sensible princess claims for it.

The term "domestic economy" has been hitherto used in so narrow and misleading a sense that there is considerable prejudice in regard to it. Its common implication is a mere improved mechanical housekeeping, or domestic drudgery made methodical, with a chief view to economy in home expenditures. The term has participated in the vulgarity that attaches to the menial and servile associations of the kitchen, so that little books upon domestic economy are thought the proper things to put into the hands of cooks and hireling housekeepers. But domestic economy, as something "which properly lies at the root of the highest life of every true woman," is a very different thing, implying culture and intelligence in the whole circle of home duties and responsibilities, and the consequent renovation and elevation of the domestic sphere. This view happily begins to be more clearly and widely appreciated. We have just read with great interest a lecture on scientific housekeeping delivered by Mrs. Arthur Bate before the Popular Science Society at Milwaukee College, which explains in an admirable

way how many new subjects and questions there are upon which women require to be trained in order to make them competent and skillful administrators of home affairs. Mrs. Bate shows conclusively that science has exactly the same office to perform in guiding domestic art that it has had to perform in giving efficiency to all the other arts, and that it will confer the same interest and dignity upon household affairs that it has already conferred upon other departments of activity. She well observes that in gaining the knowledge necessary to make the home a sanitarium—the house of health—educated housekeepers would do more to emancipate the world from fleshly ills than doctors have ever done or ever can do.

Mrs. Bate makes an important point in showing that the ignorance of women is a fatal hindrance to the introduction of many improvements by which domestic operations could be greatly facilitated, if only housekeepers knew enough to make them available. An illustration of this is just now at hand. The use of gas-stoves for cooking is one of the most important ameliorations that have been conferred upon the kitchen in a long time; but, as that realm is given over to tradition and blind habit, but little advantage has been taken of the improvement. Gas-stock holders are losing their sleep for fear Edison is going to destroy their business, but, if the benefits to be gained by the consumption of gas in cooking were generally understood, there would be but little occasion to fear from a diminished consumption of the article. A lady trained in the South Kensington Cooking-School, and who has taught in the Culinary College of Edinburgh, has recently come to this country and given a course of demonstrative lessons in cookery in New York. Her mode of working has been a sort of new revelation to the large class of ladies which has attended her instructions. Cooking has hitherto been associated with dingy kitchens and fiery ranges that evoked the free perspiration of the attendant; but Miss Dods uses a gas-stove, and does her work so neatly that it might be carried on in a parlor. In the dozen lessons she gave, scores of dishes of all kinds were prepared rapidly by the use of gas, and that they were well made was sufficiently evinced by the eagerness of the ladies to purchase them at the close of each lecture. To a curious inquirer she said, that in her practical demonstrations she had cooked by gas alone for years in preparing hundreds of dishes of a great variety in teaching. This is but one example, of which many might be cited, showing how people suffer in their domestic life because women are not properly instructed in the principles of practical household art, and in the resources that might be commanded for its improvement.

LITERARY NOTICES.

THE BIBLE OF TO-DAY: A Course of Lectures by Rev. JOHN W. CHADWICK. New York: G. P. Putnam's Sons. Pp. 304. Price, $1.50.

ON a subject of profound interest throughout Christendom, and upon which there is great discordance of opinion, coupled with intense feeling, Mr. Chadwick has produced an independent and instructive work, which is at the same time both reverent and rational.

The more liberal and catholic spirit of modern inquiry is undoubtedly due to the influence of science, which reaches far beyond the field of physical experiment. The attacks upon the Bible by the skeptics of the last century were made in the spirit of the age, which was polemical and disputatious, as it had been from the middle ages. Discussion was filled with the irritations, acerbities, bitterness, and the rancors of personal controversy. The Bible was argued over much like a party at the bar of our courts by the lawyers, one of whom wishes to set him free and the other to get him hanged. The Bible was attacked, as it was

defended, and in spirit the skeptics were as much theologians as their opponents. But science has very much changed all this, and what was long an exasperating controversy is now becoming a quiet and rational investigation. While in the disputatious era it was maintained, on the one side, that the Bible is an exceptional and supernatural book—the plenary inspiration of God, and all its parts perfect and infallible—on the other hand, it was asserted to be a fabrication and an imposture. We have now pretty much passed out of that phase, and entered into the phase of calm and critical inquiry as to the origin and history of the various books which appeared at different times, and were at length collected to form the Christian Scriptures. The inquiry should be candid and dispassionate, but conducted with inexorable reference simply to the establishment of truth.

Much has been done in recent years, by scholars of various countries, to throw light on the historic origin of the Biblical books, and Mr. Chadwick has done the public an invaluable service in presenting, in a compendious form, the main results of this most interesting research. Of his treatment of the subject the author says:

"My object is to condense into a single volume, modest in size and cost, the principal results of the best historical and scientific criticism of the separate books of the Bible, and of their mutual relations. I am not aware of any other volume which has made exactly this attempt, and it is high time that somebody should make it. The truth of these results, if truth it be, is scattered up and down through scores of volumes, which few public libraries, even in our great cities, have upon their shelves, and which it would cost the individual reader hundreds of dollars to procure. Nevertheless, I shall be disappointed if one effect of these lectures is not to impel the reader to procure for himself some of the books which I have found most helpful and inspiring. Much, however, that has been written is not only costly and inaccessible, but is so laboriously and minutely critical in its form as to repel the average reader. I dare not hope that my own treatment will be entertaining, but for busy men and women I trust it will have some advantage over that of the great Biblical scholars in that it is at once compact and comprehensive."

Mr. Chadwick's volume consists of eight lectures, which were first delivered to his own people in Brooklyn—four on the Old Testament, one on the Apocrypha, and three on the New Testament. The first is on the Prophets, and is preceded by a brief history of the Old Testament canon. The arrangement of the lectures is intended to be simply chronological, and the prophets are considered first because it was evidently Mr. Chadwick's idea that, with some inconsiderable exceptions, we have in the prophets the earliest writers of the Old Testament. The Histories are next considered, because these are believed to have been written, for the most part, before the "Law."

The "Psalms and other writings" come last, as being written after the "Law." The Prophets are first taken in the order of our common version, and the date and authorship and character of each discussed. An inquiry is instituted as to the nature of prophetism, and reasons are assigned for the belief that the early prophets were not monotheists; the writing prophets of the eighth century B. C. being probably the first monotheists.

In his lecture on the Histories Mr. Chadwick finds them not to be histories in the ordinary sense of the word, but didactic compositions. In his lecture on the Pentateuch Mr. Chadwick considers it as a stratified series. The oldest or bottom layer, richest in narration, is a prophetic one, dating from the eighth century before Christ. The next layer he designates as priestly-prophetic, and which includes the whole of Deuteronomy. Its date is fixed at 621 B. C. The next and topmost layer is altogether priestly, and includes all of Leviticus, a good deal of Numbers, and much besides. This upper stratum is what critics call the *Book of Origins*, and its date is the crucial question of Old Testament criticism. And Mr. Chadwick, following Kuenen, assigns it to the fifth century B. C., and 800 years after the time of Moses. By this mode of treatment he apprehends the entire history of Israel as an evolution from a simple to a complex worship, from the spontaneity of prophetism to fixity and formalism, from fetichism and Nature-worship up through monolatry to monotheism.

In the fourth lecture these principles are applied to the Psalms and other writings. In regard to the Psalms, Proverbs, Ecclesiastes, etc., the old interpretations are

thoroughly traversed. The Song of Songs is characterized as a very noble poem, and the earliest complete book in the Old Testament, its date being about 800 B. C.

The Apocrypha is treated as the "missing link" between the New Testament and the Old. The apocryphal literature goes a great way, and shows how gradual was the evolution from Malachi to Jesus. The book of Enoch, which only the Abyssinian canon has retained, is further evidence of this, and is of the first importance. We are now already in the New Testament atmosphere, especially in that of the Apocalypse.

The sixth lecture, after a brief history of the formation of the New Testament, proceeds to consider the Epistles. Of the fourteen commonly ascribed to Paul only eight are found to be authentic—Romans, Galatians, and Corinthians, surely so; the others not so certainly. From Thessalonians and Philippians we have the evolution of Paul's ideal Christ from simple manhood to superangelic power and grace.

In the seventh lecture the Apocalypse is assigned to the year 69 B. C. The last lecture is on the Four Gospels, and Matthew is assigned to the year 100 A. D.; Luke to 115 A. D.; Mark to 120 A. D.; and John to 140 A. D.; these dates are, however, only approximate. A full chronological table, setting forth the dates of all the separate books of the Bible, is prefixed to the volume, in the shape of an analytical index.

This book represents a great amount of labor and research, and is executed in a manner highly creditable to the scholarship of the author. Though following the great authorities that have preceded him, he is not a servile follower but an independent student. The style of the work is spirited and attractive, and it is inspired with a moral earnestness and a reverent sincerity that will commend it to all unprejudiced and fair-minded readers.

STOCK-BREEDING: A Practical Treatise on the Application of the Laws of Development and Heredity to the Improvement and Breeding of Domestic Animals. By MANLY MILES, M. D., late Professor of Agriculture in the Michigan State Agricultural College. D. Appleton & Co. Pp. 424. Price $1.50.

WE have here a timely and valuable manual upon a subject the practical importance of which is only equaled by its theoretical interest. A well-digested treatise on the art of cultivating animals through the control of genetic conditions has been long needed. Upon this point the author justly observes, "It is somewhat remarkable, in this book-making age, that there is no systematic work accessible to the student in which the known facts and principles of the art of improving and breeding domestic animals are presented, in convenient form, for study and reference, notwithstanding the importance of live-stock to the farmer, and the wonderful progress that has been made in its improvement since the time of Bakewell." The art of breeding was long pursued empirically, and was developed by numberless experiments from which rules were deduced that, though not rationally understood, were still sufficient to guide breeders in the improvement of stock. Modern biology has given greater precision to observations, has indicated new lines of experimental research, and has established various principles that are of controlling utility in practice. Much is still unsettled, and many questions remain in profound obscurity, yet there has been such a clearing up of old difficulties and such an extension of positive knowledge in this field that it is now necessary to deal with the subject from the scientific point of view. Dr. Miles's work is rich in the varied facts which constitute the foundation of the art, and which have been selected with careful judgment in regard to their authenticity, but in the classification and interpretation of his data the author follows the scientific method. Indeed, if a book were to be selected simply to illustrate the practical fruitfulness of modern scientific inquiry, in one of its most recent lines of exploration, we are inclined to think the present volume might well be chosen for the purpose. The book is so full of interesting and valuable information that we should like to transfer large portions of it to our columns; but, as this is impossible, we must content ourselves with quoting a few remarks from the author's preface, indicating the main features of his work:

"In a popular exposition of the principles of an art that is almost exclusively based upon the experience of practical men there is little opportunity for originality, aside from the classification and arrangement of facts, and the infer-

ences, in some instances, that may be drawn from them in explaining the practices of the most successful breeders. It is believed that a systematic statement of what is already known in the practice of the art is of greater importance, at the present time, than any new truths, as it must furnish the only consistent foundation for future progress and improvement. The numerous cases that have been collected to illustrate the various topics under discussion have been compiled, as far as possible, from original sources, and presented in their original form—preferences, in nearly all cases, being given to the works from which they are quoted. This feature of the work will be of interest to the student who wishes to study the subject in greater detail, as it will, to some extent, serve as an index to authorities that may be profitably consulted. In the limits of a popular work it is of course impossible to treat each topic exhaustively, and the attempt has been made to present only such an outline of the principles of the art as would be required in a text-book for students, or a work of reference for farmers."

OUTLINES OF ONTOLOGICAL SCIENCE; OR, A PHILOSOPHY OF KNOWLEDGE AND OF BEING. By HENRY N. DAY, author of "Psychology," "Logic," "Ethics," etc. New York: G. P. Putnam's Sons. Pp. 441. Price, $1.75.

THE present work is an attempt to grapple with the profoundest problems of philosophy by determining the nature and limits of genuine knowledge, and to determine the relations and interdependences of its several parts. The author claims for his book nothing of novelty in its design, but alleges, as a reason for undertaking it, that "the recent rapid developments of science, both mental and physical, with their widely-diversified results, seem to invite a fresh endeavor in this direction, as they furnish new facilities and helps for prosecuting it." As might be expected from the point of view here taken, modern scientific and philosophical ideas are brought under review and estimated, the result being, as we gather from the writer, that fundamental questions of speculative inquiry have not been much disturbed by modern research. In his last chapter on "Cosmogony" the author takes up the doctrine of evolution, which he says is philosophically "mere hypothesis," "irreconcilable with facts claimed to be ascertained by science," "repugnant to reason," and "as a theory of causal agency in the cosmos is a failure."

LIFE IN OTHER WORLDS: including a Brief Statement of the Origin and Progress of Life in our World. By ADAM MILLER, M. D. With an Appendix of Three Sermons by Rev. H. W. Thomas, D. D. Chicago: Fox, Cole & Co. Pp. 282. Price, $1.50.

A BOOK of multifarious speculations, theological, historical, moral, astronomical, and physical. The author says that it was originally written with no intention of publication, but he got so much comfort out of the contemplations it embodies that he was impelled to print it. He remarks, "With a hope that some one who will read these pages will find encouragement for a union in the great future with friends that have gone before, as well as for an acquaintance with the millions of happy spirits who have passed through the vale of sorrow to their final home, I submit this work to a generous public." Our attention has been especially called to the author's three chapters on "Solar Light and Heat," in which he differs from the ideas that men of science are in the habit of taking. The cause of solar heat he holds to be the refraction of light, and says: "The atmosphere that surrounds our earth is in the form of a concavo-convex lens. The aqueous vapor in the upper regions of the atmosphere is intensely cold, yet, acting on the rays of light like a cold-water lens, produces heat; and here is the secret of solar temperature on the earth, and the change in temperature is caused by the varying angles at which the solar rays strike the atmosphere. I repeat, it cannot be denied that refraction of the rays of light will produce heat. The heat at the focus of a 32-inch lens exceeds almost every kind and intensity of heat known to terrestrial chemistry. Again, it cannot be denied that the earth's atmosphere is a refracting medium, and that as such it is capable of producing heat from rays of light."

The book is printed on tinted paper, and contains a portrait of the author.

FILTRATION OF POTABLE WATER. By Prof. WILLIAM RIPLEY NICHOLS. From Massachusetts Health Reports, 1878. Pp. 90.

THE author of this valuable report considers the subject of filtration under the three heads of "Artificial Filtration on the Large

Scale," "Natural Filtration," and "Household Filtration." The two former sections will be read with interest by the civil and sanitary engineer; the last, that on "Household Filtration," directly concerns every family in the land. Too often the quality of water supplied to the inhabitants of our cities is truly described as in the following reply to a letter of inquiry: "When the river is clear we have clear water; when the river is muddy we have muddy water." Such a state of things necessitates the use of domestic filters, many different forms of which are described and criticised by Dr. Nichols.

THE OLD HOUSE ALTERED. By G. C. MASON, Architect. With Illustrations. New York: G. P. Putnam's Sons, 1878. Pp. 185. Price, $2.50.

THE problem here considered is one that is every day arising for solution—how to modernize and beautify an old house. In a series of chapters which take the form of familiar letters the author first describes the original form of an old mansion; then details the changes in its internal arrangement and in its exterior, necessitated by the requirements of modern life and of modern culture; finally, he tells us how these changes have been made. Nor does Mr. Mason restrict himself to the consideration of the purely architectural aspects of the problem, for the old mansion had to be transformed not only in itself, but also in its fittings and furniture. There is room for difference of opinion as to the desirability of such transformations, and most persons would perhaps think it the better way to pull down and build anew; but, if regard for an old house interferes to prevent its demolition, our author's plan of transforming and modernizing it will deserve to be considered.

GOETHE'S FAUST. ERSTER THEIL. With Introduction and Notes by JAMES MORGAN HART. New York: G. P. Putnam's Sons, 1878. Pp. 286. Price, $1.25.

THE first part of "Faust" forms Vol. IV. of Prof. Hart's series of "German Classics." The English student of German will derive from the editor's very brief grammatical and critical notes, and from his learned introduction, material aid in overcoming the difficulties of the text.

PRACTICAL CHEMISTRY FOR MEDICAL STUDENTS. By M. M. PATTISON MUIR. London and New York: Macmillan & Co., 1878. Pp. 64. Price, 60 cents.

THE medical student will here find precisely that measure of information in practical chemistry which is *absolutely indispensable* for him to possess. The author's object is in no wise to "cram" the student for examination-day, but to put him in possession of a few chemical principles, and to familiarize him with certain chemical processes, without which he cannot hope for success in his chosen profession.

THE BLESSED BEES. By JOHN ALLEN. New York: G. P. Putnam's Sons, 1878. Pp. 169. Price, $1.

UNDER this quaint title, Mr. Allen publishes the record of a year's experience and results in bee-keeping. Persons who may be thinking of engaging in that pursuit will doubtless learn much from this little book. Bee-keeping, by modern methods, the author informs us in the preface, is an art just as much as growing wheat or fruit or stock; the profits which may be gained from it are just as certain as the profits from any other branch of rural labor, and are much larger.

THE RELATIVE PROPORTIONS OF THE STEAM-ENGINE. By WILLIAM D. MARKS. Philadelphia: Lippincott, 1878. Pp. 161. Price, $1.50.

A LONG-FELT want is here supplied, viz., simple, practical formulæ for the determination of the relative proportions of the component parts of the steam-engine. Rankine appears to be the only author in English who has attempted to do this; but his treatment of the subject is so brief as to be obscure. The present work is therefore a very welcome contribution to the science of the steam-engine.

FLOWER-PAINTING. By Mrs. WILLIAM DUFFIELD. New York: G. P. Putnam's Sons, 1878. Pp. 46. Price, 50 cents.

THE fact that this handbook of flower-painting has already passed through twelve editions in England speaks well for its popular character. Like all the volumes of the series of "Art Handbooks" to which it belongs, it is a model of tasteful book-making.

THE RAILWAY IN ITS RELATION TO PUBLIC AND PRIVATE INTERESTS. By SIMON STERNE. New York, 1878. Press of the Chamber of Commerce. Pp. 38.

MR. STERNE advocates governmental control of the railway lines. The cry that this is "centralization" does not frighten him, because "whether centralization is objectionable depends upon whether it is good or bad, and whether it supersedes a better or a worse system." And he quotes with approval the remarks made by Burke: "If I am not able to correct a system of oppression and tyranny that goes to the utter ruin of 30,000,000 of my fellow-creatures, but by some increase of the influence of the crown, I am ready here to declare that I, who have been active to reduce it, shall be as active and strenuous to restore it again. I am no lover of names; I contend for the substance of good and protecting government, let it come from what quarter it will."

GOLDEN SONGS OF GREAT POETS. Illustrated by Darley, Moran, Hart, Fredericks, Smillie, and McEntee. New York: Sarah H. Leggett. Price, $5.

FEW books have fallen into our hands having a more distinguished paternity than this one. It contains six poems, not elsewhere published, from six of the leading American poets of the century, and its pages are embellished with thirty-six beautiful illustrations, by artists of scarcely inferior rank. Holmes contributes the introduction, "On the Threshold;" Bryant follows with a pleasant bit of Nature entitled "The Song Sparrow;" and Longfellow writes of what he is supposed to know most about, "The Poets." "June on the Merrimac," by Whittier, is a gem well worth the price of the book, and there follows Lowell on "The Fire-Fly," and Bayard Taylor on "The Lost Caryatid." The printer and binder have done their share of the work in befitting style, making the volume, taken altogether, one of the handsomest and most interesting holiday books we have seen.

GEOLOGY OF WISCONSIN. Vol. II. Madison: Published by the Commissioners of Public Printing, 1877. Pp. 797.

THOUGH this volume is numbered II., it is in fact the first of the series in the order of publication, and Vol. I. is yet to follow. The reason of this reversal of the logical sequence is that, while the matter belonging to Vol. II. is completed, that which of right belongs to Vol. I. has to await the completion of the survey. The volume, which, by-the-way, is highly creditable to Wisconsin lithography and typography, consists of four parts, viz.: Part I., containing the annual reports for 1873, 1874, and 1875, now first published. During the two former years, the survey was under the general direction of Dr. Increase A. Lapham, and during the last year under Dr. O. W. Wight. Part II. treats of the geology of Eastern Wisconsin, and is written by the geologist-in-chief, Mr. T. C. Chamberlin. Part III., by Roland D. Irving, treats of the geology of Central Wisconsin. Finally, Part IV., on the "Geology and Topography of the Lead-Region," is by Moses Strong. Accompanying the volume is a set of maps, fourteen in number. Numerous colored and plain lithographic plates and wood-engravings serve to embellish the volume and to illustrate the text.

FIRST ANNUAL REPORT OF THE UNITED STATES ENTOMOLOGICAL COMMISSION, for the Year 1877, relating to the Rocky Mountain Locust. With Maps and Illustrations. Washington: Government Printing-Office, 1878. Pp. 787.

THE vast fund of information acquired by the Entomological Commission during the first year of its labors is in this report laid before the agricultural population of the States and Territories exposed to the locust-plague. The commissioners, Messrs. Riley, Packard, and Thomas, justly congratulate themselves on the success which has attended their efforts to determine certain cardinal points touching the origin and distribution of the Rocky Mountain locust—its breeding-grounds, geographical range, migrations, habits and natural history, the means of checking its ravages, etc. Much, indeed, has been done toward accomplishing the purpose for which the commission was appointed; but still more remains to be done, both in the way of research and, above all, in the way of applying on the large scale the remedies and devices for exterminating the locust which are here explained. "Further surveys need to be made of the permanent breeding-grounds in the Northwestern Territories; more facts are needed to perfect our knowledge of the mi-

grations in this area; the coöperation of our Government with Canada is needed to work up the subject properly in the locust-region north of the United States boundary-line; and some other problems remain to be solved." This done, it is hoped that it will be "possible at least to greatly modify or lessen these invasions, and diminish the losses resulting therefrom, if not entirely prevent them."

DANGERS FROM COLOR-BLINDNESS IN RAILROAD EMPLOYEES AND PILOTS. By B. JOY JEFFRIES, M. D. Pp. 40. INCURABILITY OF CONGENITAL COLOR-BLINDNESS. Pp. 8. COLOR-BLINDNESS AND ITS PRACTICAL RELATIONS. Pp. 4. Same author. Boston: Rand, Avery & Co. print.

THE very title of the first of the above-named publications will win for it the earnest attention of the public. The dangers from the color-blindness of railroad-men and pilots are obvious, and it is time that efficient measures should be taken to obviate them. The Massachusetts Board of Health is to be highly commended for having procured the publication of Dr. Jeffries's observations on this subject.

ELEMENTARY COURSE OF GEOMETRICAL DRAWING. By G. L. VOSE. Illustrated by 38 Plates. Boston: Lee & Shepard, 1878. Price, $5.

THIS course is designed to meet the wants of the lower classes in engineering schools; it will also be of service to those who wish to pursue this branch of study by themselves. The system here followed has been subjected for many years to the test of practical experience in the class of civil engineering in Bowdoin College.

PUBLICATIONS RECEIVED.

Report of the Chief Signal-Officer for the Year 1877. With numerous Charts. Washington: Government Printing-Office. 1877. Pp. 570.

A Face illumined. By E. P. Roe. New York: Dodd, Mead & Co. Pp. 658. $1.50.

Report of the Board of Regents of the Smithsonian Institution for the Year 1877. Washington: Government Printing-Office. 1878. Pp. 500.

The Telegraph in America. By James D. Reid. With numerous Portraits. New York: Derby Brothers. 1878. Pp. 846. $6.

The Races of European Turkey. By Edson L. Clark. New York: Dodd, Mead & Co. 1878. Pp. 538. $3.

Daily Bulletin of Weather-Reports for January, February, and March, 1877. Washington: Government Printing-Office. 1878.

First Quarter Century of the Home Insurance Company. New York: Printed by order of the Board. 1878. Pp. 80.

Astronomy. By R. S. Ball. New York: Holt & Co. 1878. Pp. 167. 60 cents.

Science News. Published fortnightly by S. E. Cassino, Salem, Mass. Vol. I., No. 1. Pp. 16. $2 per annum.

Geological and Natural History Survey of Minnesota. Report for the Year 1877. Minneapolis: Johnson, Smith & Harrison. 1878. Pp. 225.

Third Annual Report of the Johns Hopkins University. Baltimore: Murphy print. 1878.

Annual Report on the Operations of the Department of the Interior for the Year ending June 30, 1878. Washington: Government Printing-Office. Pp. 48.

An Essay on Free Trade. By Richard Hawley. New York: Putnam's Sons. 1878. Pp. 63. 25 cents.

Dissipation of Electricity in Gases. By Demetrieff Bobouleff. From the *American Journal of Science and Arts*. Pp. 13.

Report of the New York Association for improving the Condition of the Poor. Pp. 64.

Laws affecting Tenement and Lodging Houses in New York and Brooklyn. Printed by the Association. Pp. 11.

Constituents of Climate, with Special Reference to Florida. By F. D. Lente, M. D. Louisville, Kentucky: *Richmond and Louisville Medical Journal* print. Pp. 56.

On the Genealogy of Plants. By Lester F. Ward. Pp. 378.

Report of the Survey of the Northern and Northwestern Lakes and the Mississippi River, in Charge of C. B. Comstock and M. H. Adams. Washington: Government Printing-Office. From Report of Chief of Engineers. 1877. Pp. 100.

Catalogue of the *Iron Age* Library. New York: David Williams. Pp. 50.

General Vaccination throughout the Country. By Elisha Harris. Pp. 16. Records of Deaths and Causes of Death. Same author. Pp. 16. From Papers of the American Public Health Association. Cambridge: Riverside press. 1877.

Art Anatomy. By A. J. Howe, M. D. Pp. 23.

Note on Cladocera. By Edward A. Birge, Ph. D. With Plates. Pp. 34.

A Collection from the Ancient Cemetery at the Bay of Chacota, Peru. By John H. Blake. Printed at the Salem press. Pp. 304.

The Halifax Fishery Award. By Alexander Bliss. Washington: Beresford print. 1878. Pp. 24.

American Jurassic Dinosaurs. By O. C. Marsh. With Plates. Reprinted from *American Journal of Science*. Pp. 6.

Evolution of Character. By J. I. D. Hinds. Nashville, Tennessee: Ligon & Co. print. Pp. 11.

Air and Moisture on Shipboard. By T. J. Turner, M. D. Pp. 16.

Chemical Constitution of the Atmosphere. By Albert R. Leeds, Ph. D. From Annals of New York Academy of Sciences. Pp. 27.

Eradication of Syphilis and Crime. By George F. French, M. D. Portland, Maine: Berry print. Pp. 8.

Conservation of Force. By Thos. H. Musick. Mexico, Missouri: *Union* print. 1878. Pp. 56.

The Amateur's Handbook of Practical Information for the Workshop and Laboratory. New York: The Industrial Publication Co. 1878. Pp. 44. 10 cents.

Natural Succession of the Dicotyledons. By Lester F. Ward. From the *American Naturalist*. Pp. 11.

POPULAR MISCELLANY.

What Medicine owes to Galileo.—In a lecture on the history of instruments of precision in medicine, a synopsis of which is published in the *Medical Record*, Dr. S. Weir Mitchell gives to Galileo Galilei the credit of having contrived the first instrument of this kind, viz., the pulsilogon. Desiring to apply some test of the regularity of the swing of the lamp-pendulum in the Pisa cathedral, he is said to have used that most wonderful of clocks, the pulse, for that purpose. This was a grave moment in the history of medicine—"the birth of precision," says Dr. Mitchell. From this use of the pulse as a test of the regularity of the pendulum he was led to use the pendulum as a measure of pulse-rate—thus making the pendulum a *pulsilogon*. The method of using it was most ingenious. Having always a pendulum of equal weight, he set it swinging, and then shortened or lengthened the string until the beats corresponded with those of the patient's pulse. Then he measured the length of the string, and one person's pulse would be represented arbitrarily but most precisely by say ten inches, another's by eight inches, and so on. Galileo seems to have given little thought to the perfection of this instrument, and does not speak in any of his essays of the medical use of the pendulum. Many years later Sanctorius described an instrument for measuring the pulse which was in no respect different from that of Galileo, and which was called by the same name—pulsilogon.

Plant-Respiration.—From experiments made by Mr. J. Jamieson, and published in *Nature*, it would appear that fresh sections of many fruits and other vegetable structures, as potato, give the characteristic reactions of ozone, viz., causing separation of iodine from iodide of potassium, and turning tincture of guaiacum blue, the intensity of the reactions depending mainly on the comparative freshness of the fruits and vegetables. Mr. Jamieson further finds that these structures contain a substance which acts as an ozone-carrier, or *Ozonträger*, to use Schönbein's expression, a substance which transfers ozone from hydrogen-peroxide, and similar bodies. This is shown by the fact that, if the guaiacum is not blued at all, or only slightly, the blue color becomes very marked when a drop of ethereal solution of hydrogen-peroxide is added. From these observations the author infers—1. That the oxygen inhaled by living plants, and even by pulled fruits, for a time is ozonized, probably by entering into loose combination, as is the case with oxygen in the blood of animals; and, 2. That it is probable that the ozone-transferring substance existing in almost every fresh vegetable structure is that with which it is loosely combined, as the oxygen in the blood is with the hæmoglobin of the red corpuscles. This element in plants is gradually destroyed as decay comes on, and ceases to perform its ozone-transferring function when the fruit, etc., containing it is cooked. It is not chlorophyl, as is shown by its situation, and it seems to be intimately associated with the vascular tissue. From analogy with the animal substances, hæmoglobin, fibrin, myosin, etc., which have a similar action, it may be presumed to be proteinaceous, though the author is unable more exactly to indicate its chemical and other characters.

Growth of Mining Engineering in the United States.—Thirty years ago the profession of the mining engineer was almost unknown in the United States; to-day the American Institute of Mining Engineers numbers over 700 members. The state of things which existed thirty years ago will be understood from the following passage, which we take from Mr. E. B. Coxe's presidential address to the members of the Institute at its last meeting: "Of the few we then had worthy of the name of 'mining engineer,' some studied in the Continental academies, and others were graduates in the school of practical experience, and had learned their profession in mines and smelting-works. Their work consisted principally in making surveys and maps of mines and mining properties, geological reports, and analyses of ores; but the mining engineer, whom we often meet with now, who has studied chemistry, physics, mineralogy, geology, mechanics, and drawing; who is more or less familiar with machinery and its construction, and with the practical

management of mines or smelting-works, and who is an *expert* in some one branch of his profession—would have been very difficult if not impossible to find in the United States. The inducements held out to ambitious and talented young men to enter the profession were, it must be admitted, very small. By a large portion of the community, a mining engineer was considered to be merely a bait with which unsophisticated capitalists were to be caught, and his opinions were considered to be worth so much a page, and to favor any view which his employer wished to have advocated. He was seldom consulted as to the proper method of working a mine or running a furnace; he was rarely called upon by directors of works, except for extraordinary work, such as to give the direction in which a tunnel should be driven, or to analyze a new ore or limestone. There was no recognized standard in the profession, and there were great openings for unprincipled adventurers, of which many charlatans took advantage. Up to within fifteen years, mining engineers were too often regarded by those who had dealings with them with great distrust, and well-educated persons may yet be found who have no idea what a mining engineer is, nor what he is called upon to undertake. This feeling is, however, wearing away. We now have mining engineers whose names are as well known abroad as at home; whose opinions are respected and paid for, although, I am proud to say, they cannot be bought. We have schools whose graduates are well qualified to enter the ranks of the profession when they have obtained the proper practical experience; and there are few parts of the country without mining engineers of established reputation, unless, in consequence of the peculiar condition of the locality, there is no need of their services."

Studies of a Mummy.—Mr. Frank Buckland, having received from a friend who had been visiting Egypt a mummy-head, set about examining the curiosity, with what results he informs us through the columns of *Land and Water*. From the general contour of the head he infers that it is that of a woman. The actual features cannot be seen, being covered with a sort of mask of linen cloth. Underneath this can be discerned the outlines of the face; the pupils of the eyes are marked with a black spot. The mummy wears a wig! Mr. Buckland found the whole head covered with what at first appeared to be rolls of hair, but which turned out to be an imitation of hair. The rows forming this wig are arrayed in three tiers, overlapping each other. The lowest tier begins from the top of the ear, and runs almost straight across the forehead; it is not unlike the fashion of hair worn by some ladies of the present day. "To try the effect," adds Mr. Buckland, "I put a modern, smartly-trimmed hat on the head of this Egyptian lady. I see that the fringe of hair is the same as the fringe of the present time. On the whole, there is a little more *chic* about it." Having washed one side of the mummy's face with warm water and a sponge, and again put on a modern hat, he was more convinced than ever that the head is that of a lady—"very good-natured and smiling."

Effects of English Rule in India.—Mr. C. Macnamara, surgeon to the Westminster Hospital, London, was for twenty years engaged in practice in India, and during that time had every opportunity of learning the feelings and opinions of the natives regarding the present state of things in that country. According to Mr. Macnamara, the deep and growing conviction of many of them is that, although England has in India preserved many millions of human beings from the calamities of anarchy and chronic warfare, nevertheless native society is becoming rapidly disorganized. A vast number of the old families have disappeared; the mothers and wives of the rising generation see their educated sons and husbands given over to vices formerly never heard of, utterly heedless of family or any other ties, and they contrast all this with times past, when there was not so much law, education, or taxation, but when the greatest stain that could be cast on a man's name was that of being an undutiful son. In Mr. Macnamara's opinion all this results from "purely secular education." The rising generation of educated Hindoos break away from the native religion, entirely ignore the existence of a God, and live absolutely for self. "The outcome of a

purely secular education," writes Mr. Macnamara, "is gross materialism and rank socialism. Hence the necessity of suppressing the vernacular press, a measure calculated, it may be, to smother for a period one of the many outlets by means of which Europeans had an opportunity of ascertaining the state of feeling among the natives of the country, and which [*sic*] I fear will too certainly burst forth in an insurrection in comparison with which the mutiny was a mere brawl."

Our Parks.—In a recent paper on "Our Parks," read before the New York Academy of Sciences, Dr. E. Seguin vigorously protests against the policy that is rapidly surrendering the Battery to commercial uses, and destroying its value for æsthetic and health-giving purposes. The beautiful view of the harbor which the Battery once afforded is gradually being narrowed: to the west by Castle Garden, formerly a simple terrace—a lookout, now an immigrant-shed; toward the east six buildings form an immense barrier, behind which none would suspect how near the ocean displayed its ever-changing scenes; from the sea the city looks as if inclosed by barracks, from the land it is the sea that appears to be imprisoned. The little space for an outlook remaining is now threatened with invasion by Government buildings, the city consenting with offers of additional land if required. A total obstruction of the view will follow next, completing the severance of the city from the bay, and presenting the shocking contrast of a harbor unequaled in grandeur leading up to a row of barracks on the water-front—no monuments in view, the ocean-breeze shut out, all perspective destroyed; the whole scene a violence to the eye and an humiliation to patriotic pride.

Preceded by the destruction of St. John's Park, and the attempt of last year to ruin the Washington play-ground, Dr. Seguin regards this as a third plot against the best interests of the city, coolly set to execution for no *apparent* purpose save the destruction of what is both a health resort and a powerful educating agency for the children and youth of the metropolis; and thus blunting the sense of the beautiful by cutting them off from the enjoyment of the natural scenery of which New York, above all other cities, is the fortunate possessor.

All right-thinking people will agree with Dr. Seguin that an exactly opposite policy should be adopted and carried out by the municipal authorities. This whole shore up to its original limits should be thrown open to the bay, and made to present to the stranger the noble face of a great city, the hospitable welcome of a great nation. It should be made an entrance of honor for distinguished guests, where the greetings of a cultured people could not be drowned by the rush and turmoil of trade. It should be rescued from its present and prospective degradation, and, by a wise combination of Nature with art, converted into a school for the millions that in future generations would make it a resort. To this end says Dr. Seguin: "The waves of the bay should be made to expire in marble basins, fronting the widened entrance to Broadway, perceptible through the trees. Where the land and water meet the vegetation, transformed from terrestrial to aquatic, may extend from the shore to the reefs beyond, and here also could be established subterranean aquaria, whose population might be made more varied and rich in the life of the sea than that which now delights and instructs the visitors at Brighton." Dr. Seguin gave several interesting illustrations of the great influence exerted by early impressions in shaping the future of the individual, and contended that every opportunity should be seized to make such impressions contribute to elevation of character, and to the encouragement of noble aims. He also called attention to the advantages that would follow the union of outdoor with indoor teaching by what he terms the mobilization of the schools.

The Light of the Sun's Corona.—Before the occurrence of the solar eclipse of 1878, Mr. W. T. Sampson, U. S. N., made elaborate preparations for studying minutely the corona's spectrum, with the sole view of deciding, by the absence or the presence in it of dark lines, whether the light is reflected sunlight, whether it is due to the self-luminous matter of the corona, or whether it is due to both of these causes combined. In the *American Journal of Science* he

describes the instruments used for this research, and the manner in which they were employed. His conclusion is that, inasmuch as he failed to see in the corona spectrum the dark lines of the sun's spectrum, therefore the light of the corona is *not all* reflected light. The considerations which confirm him in this conclusion he states as follows: "Until this eclipse no observer has ever seen the dark lines in the spectrum of the corona except M. Janssen, who reported dark lines, notably D in 1871, but much more difficult to see than the bright lines. Several observers during the recent eclipse failed to see the dark lines, though they looked for them carefully. While I do not question the results of observers who report the presence of dark lines, I think all the observations taken together show that the continuous spectrum of the corona is not the spectrum of the sun. Aside from this, Prof. Arthur W. Wright made measurements of the polarization of the light of the corona, the first time, I think, it has been attempted, and has found the polarization to be but a small percentage of the whole light emitted. Although all reflected light does not reach us as polarized light, yet I think the small percentage of polarization, taken with the faintness of the dark lines, indicates that the corona is, to a considerable extent, self-luminous. The meteoric dust not only reflects the sun's light, but it is continually showering upon the sun, and in its passage through the atmosphere is rendered incandescent."

Investigating the Cotton-Worm.—Prof. A. R. Grote is at present visiting the cotton-growing States for the purpose of studying there the habits of the cotton-worm, and more particularly of determining whether the fly from which it comes is acclimated in those States, or whether it is annually imported. The latter opinion, as our readers are aware, is the one held by Prof. Grote, and it appears to be confirmed by this later investigation. According to his theory, the fly comes from the West Indies with the south winds every year. Having reached our cotton-producing States it there raises its first brood. The eggs are deposited on the under side of the cotton-plant leaf. In about three weeks the young worm "webs up" and becomes a black chrysalis in a thin cotton-cocoon within a fold of the leaf, and in due time the perfect insect emerges. This new fly, born in the South, moves in a general northerly direction, and in this way the country is overrun by the several ensuing broods. If the worm appears while yet the plant is young, the planter can exterminate it by the use of poison; but if it comes late it will not do harm enough to warrant much expense in killing it. Paris-green in a liquid form, or dilute carbolic acid, kills the worm when applied to the under side of the leaf as spray. Care must be taken to keep these poisons from the seed-cotton, and they should only be employed against the first brood of worms before the bolls open.

An Eastern Fish-Story.—A series of interesting letters is now appearing in *Land and Water*, entitled "Recollections of Bangkok," and in one of them a good description is given of the mode of capturing insect prey, followed by a species of "archer fishes," several specimens of which are kept in a small pond in the grounds attached to the palace of the "Second King" of Siam. It is much to be regretted that the author neither describes these fishes nor notes any particulars by which the species might be determined. Our readers will find in the MONTHLY for January, 1878, an illustrated paper on "Archer-Fishes." When the writer in *Land and Water* came to the pond its finny inhabitants were found to be in a high state of excitement, the cause of which was soon evident. "A small branch covered with black ants had been picked by one of the attendants off one of the overhanging trees; and, holding this a few feet over the pond, volleys of minute globules of water were directed at it from the mouths of all the little fishes crowded underneath. This was continued until all the ants were knocked off into the water. Then ensued a scramble for the prey. Any small insect within their range met the same fate, and they shot with the most unerring aim. As I stood watching the curious sight, close to the edge of the pond, a small fly lighted on my hand, but was hardly seated before a volley of watery bullets knocked him off his perch, though at a range of four or five feet.

These little fishes are, I believe, only known in some parts of Siam and Burmah; they are small, not more than six or seven inches, and in shape like a smelt. I am not aware that I have ever seen any description of them."

"Are the Elements elementary?"—Mr. Norman Lockyer has realized the alchemist's dream, the transmutation of metals. In the presence of a small party of scientific men, Mr. Lockyer, by the aid of a powerful voltaic current, volatilized copper within a glass tube, dissolved the deposit formed within the tube in hydrochloric acid, and then showed, by means of the spectroscope, that the solution contained no longer copper, but another metal, calcium, the base of ordinary lime. The experiment was repeated with other metals and with corresponding results. Nickel was thus changed into cobalt, and calcium into strontium. All these bodies, as is well known, have ever been regarded as elementary—that is, as incapable of being resolved into any components, or of being changed one into another. It is on this basis that all modern chemistry is founded, and, should Mr. Lockyer's discovery bear the test of further trial, our entire system of chemistry will require revision. The future possibilities of the discovery it is difficult to limit. The great object of the old alchemists was, of course, to transmute base metals into gold, and so far as our knowledge goes there is no reason why copper should not be changed into gold as well as into calcium. The means at present employed are obviously such as to render the process far more costly than any possible results can be worth; but this is necessarily the case with most scientific discoveries before they are turned into commercial facts. Mr. Lockyer is one of our best living spectroscopists, and no man with a reputation such as his would risk the publication of so startling a fact as he has just announced to the scientific world without the very surest grounds. He is known by his friends as somewhat sanguine, and he does not pretend to be an accomplished chemist, but he was supported yesterday by some of our leading chemists, all of whom admitted that the results of his experiments were inexplicable on any other grounds but those admitting of the change of one element into another, unless indeed our whole system of spectrum analysis is to be upset, the other horn of a very awkward dilemma. Since a hundred years ago Priestley discovered oxygen and founded modern chemistry there has been—there could be—no discovery made which would have such an effect on modern science as that the so-called elements were no longer to be considered elementary.—*London Daily News.*

NOTES.

A GOLD medal has been awarded to Mr. Edward R. Andrews, of Boston, for his exhibit of creosoted wood at the Exhibition of the Mechanics' Charitable Association in Boston. The article on the *Teredo navalis*, by Prof. von Baumhauer, in the August and September numbers of this journal, was translated by Mr. Andrews. This paper explains the merits of creosote-oil in protecting timber from destruction by marine worms and insects.

CONCERNING the manner of Mr. Thomas Belt's death, the *American Journal of Science* has the following information: "About two weeks previous to his death Mr. Belt had shown signs of insanity, and it was thought best to remove him to New York. Mr. Silas Lloyd, who had for a short time been associated with him, accompanied him. Just before arriving at Kansas City, Mr. Lloyd had occasion to leave him for a few minutes. On returning, he found the door locked. Mr. Belt refused to let him in, and commenced a furious onslaught on furniture and car. Parties crawled through the broken windows, and succeeded in pacifying him. Getting him off the train, he was prevailed upon to drink a glass of milk, and about twenty minutes afterward he died."

A NOTE was read in a recent meeting of the Paris Academy of Sciences, from Mr. J. Norman Lockyer, in which the author says that he believes he has succeeded in proving that many of the "elements" are in reality compound bodies.

THE *Iron Age* reports the discovery in Franklin County, Pennsylvania, of very rich deposits of copper, occurring in the form of hydrous carbonate or malachite, containing about seventy-two per cent. of copper oxide or fifty-seven and a half per cent. of metallic copper. Some of the deposits show even a higher percentage than this.

A MONKEY in the Alexandra Palace, London, had a decaying tooth, and suffered from a large abscess in the lower jaw. It

was decided to extract the tooth, but, as the animal was at times very vicious, it was thought that chloroform would have to be employed. He showed fight on being taken out of his cage, and struggled hard against being put into a sack, snapping and screaming at the attendants. But so soon as the dentist managed to get his hand on the abscess, and so gave a little relief, the monkey's demeanor changed entirely: he laid his head down quietly for examination, and quietly submitted to the removal of a stump and a tooth.

In a series of experiments undertaken with a view to discover an effective method of preserving animal substances, Dr. B. W. Richardson discovered that flesh which is alive in the body of an animal possesses a neutral reaction, being neither acid nor alkaline; but that after an animal is killed, and the flesh is exposed to the air, there is quickly set up an acid reaction which lasts as long as the dead structure remains "fresh." As the structure begins to change, the acid reaction becomes neutral, and from that it soon passes to become alkaline. This alkaline reaction may be considered as an evidence of putrefaction.

A select committee of the National Academy of Sciences, appointed to consider what changes are needed in the conduct of the surveys of our Western States and Territories, has made a report in which they recommend a radical change. They favor the abolition of the present surveys under Hayden, Powell, and Wheeler, respectively, and the transfer of the work to the Interior Department. It is proposed to make the Coast Survey the nucleus of a grand system of scientific exploration and survey.

The efforts of the Fish Commissioners of Maryland to stock the waters of that State with California salmon are proving eminently successful. At Havre de Grace and other points on the Susquehanna, salmon are beginning to make their appearance, and many of good size have been taken. During the season of 1878 three hundred thousand salmon have been distributed in Maryland waters.

A ludicrous miscarriage of justice has occurred in England. Judgment having been entered against a shopkeeper for selling watered milk to a food-inspector, appeal was made to the Lord Chief Justice, who reversed the original judgment. An appeal in Scotland has had a like result. The ground of this judgment of the higher courts is the fact that, in order to make the seller of an adulterated article liable, the sale must have been made "to the prejudice of the purchaser." But as the inspector is not "prejudiced," the seller must go free!

It is firmly believed by the people who inhabit the region around Mount Ararat that no man has ever ascended to its summit—indeed, that the feat is impossible. But precisely this *impossible* feat has been performed by an Englishman—Mr. Bryce. But the popular belief persists all the same. When Mr. Bryce told the archimandrite of the district that he had made the ascent, the old man merely smiled, and reaffirmed the impossibility of reaching the summit.

The best quality of lime-juice for anti-scorbutic purposes is produced in the island of Montserrat, West Indies, where three hundred acres of orchard-ground are devoted to this culture, the number of lime-trees being about a hundred and twenty thousand.

In advocating the projected astronomico-meteorological observatory of Mount Etna, Mr. G. F. Rodwell takes occasion to mention the extraordinary brilliancy of the midnight sky as observed by him during an ascension of Etna in August, 1877. Myriads of stars which he had never seen before were visible, and the whole sky was studded with stars of every magnitude, color, and brightness. The meteors were "too numerous to count;" the stars themselves shone with extraordinary scintillations. One effect in particular was noticed, for which it is not easy to account, viz., the apparent lowness of the sky, which "appeared to be almost pressing down upon one's head, while the larger stars seemed to be *suspended below the sky*. A good telescope," he adds, "brought to bear on such a sky would reap a harvest of results."

In the root of the strawberry-plant (*Fragaria vesca*) Dr. T. L. Phipson has discovered certain substances closely allied to those obtained from cinchona-bark. There exists in this root a sort of tannin of a very pale-yellow color, soluble in water and in alcohol, and which strikes a green color with iron salts. It is soluble in water slightly acidulated with hydrochloric acid; but with more hydrochloric acid it combines to an insoluble compound. This substance, called by Phipson *Fragarianine*, is really a sort of tannin, closely allied to quinotannic acid, but instead of yielding *cinchona red* like the latter, it yields a somewhat similar substance, which Phipson calls *Fragarine*. The process by which this substance is obtained is fully described by Phipson in a paper read before the British Association.

Iridescent glass is made by burning chloride of tin in the furnace. Fumes are thus produced for which warm glass has great affinity, and which immediately produce an iridescent surface upon it. To heighten the effect, a small quantity of the nitrates of baryta and strontia may be used.

ELISHA GRAY.